THE INFLUENCE OF FLUE SHARING ON VENTING PERFORMANCE

A Study Prepared for

CANADA MORTGAGE AND HOUSING CORPORATION

by

Scanada Consultants Limited

Scanada Sheltair Consortium Inc.

August 19, 1987

Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

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This publication is one of the many items of information published by CMHC with the assistance of federal funds.

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Principal Consultants:	John C. Haysom Michael C. Swinton Scanada Consultants Limited
Project Manager for CMHC:	A. Grant Wilson
CMHC Scientific Authority:	Jim H. White

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EXECUTIVE SUMMARY

An investigation of the effect of the sharing of flues by furnaces and water heaters on the performance of venting systems serving natural gas appliances was conducted. The investigation included -

- *a literature review,*
- *a review of applicable codes and standards,*
- *controlled field testing to investigate the effect of various water heater vent connector configurations on venting performance*
- *modification of the FLUE SIMULATOR computer model to allow it to model shared flue venting systems,*
- *calibration of the modified FLUE SIMULATOR model using the results of the field tests*
- *use of the FLUE SIMULATOR model to predict the effect of flue sharing on venting performance in a variety of situations, and*
- *development of guidelines for heating industry service personnel.*

The results of this study indicate that the sharing of flues greatly exacerbates venting problems when the conditions for proper venting are already adverse. This makes it important that both the furnace and the water heater vent connectors have "clean" flow areas with as few elbows and contractions as possible. As well, it was shown that the flow area of the venting system downstream of the furnace/water heater connection should also be as "clean" as possible. Field and modelling results were used to suggest how well various current practices in vent connector installation serve the above design objectives. It was found that configurations in which the water heater vent connector is connected separately to the flue (i.e. it does not connect to the furnace vent connector) should be the least prone to combustion venting problems.

THE INFLUENCE OF FLUE SHARING ON VENTING PERFORMANCE

INTRODUCTION

As part of its ongoing study of combustion venting problems in Canadian houses, Canada Mortgage and Housing Corporation engaged the Scanada Sheltair Consortium to conduct studies of several aspects of chimney flue performance, including -

- the influence of thermal and flow design parameters on the performance of chimneys,

- the performance of flues shared by gas furnaces and water heaters,

- the influence of flue caps and dampers on chimney performance, and

- the performance of sealed, insulated venting systems for oil furnaces.

This report deals with one part of one of the above studies - the performance of **flues shared by furnaces and water heaters.** The other studies are reported on separately.

This part of the study consisted of the following tasks:

- a literature review

- a review of applicable codes and standards

- field testing of a variety of shared flue configurations to provide data against which the FLUE SIMULATOR predictions and results of the parametric study could be measured.

- modification of FLUE SIMULATOR, a microcomputer-based model of thermal, pressure and flow interactions in the furnace/flue/house system, to allow it to model shared flue venting systems,

- calibration of the modified FLUE SIMULATOR model against the results of the field tests

- use of FLUE SIMULATOR in a parametric study of the effects of flue sharing, and

- guideline development for contractors and tradesmen on recommended practices that will avoid venting problems in shared flue configurations.

OVERVIEW

In the parallel flow system of joined furnace and water heater vent connectors, the ability of the system to resist backdrafting is as strong as the weakest branch in the system. That is, if the furnace draft hood/vent connector is successful in initiating upward flow in adverse conditions but the water heater draft hood/vent connector is not, then it can be expected that some or all of the upward flow of flue gas in the furnace branch will reverse and spill out the water heater branch. In such circumstances, the furnace branch is pressurizing the water heater branch. This is why codes have recently been modified to proscribe shared vent connectors when the furnace is a mechanically induced draft unit with positive vent pressure (see further discussion below) - the superiority of the furnace branch is so great when mechanically driven that the water heater branch can be expected to spill regularly.

Current Water Heater Vent Connector Practice

Discussions with senior gas inspectors and old-time furnace servicemen indicate that by far the most common style of vent connection is a "Y" connector with a 100 mm (4 inch) diameter water heater connector joining a 150 mm or 175 mm (6 or 7 inch) diameter furnace vent connector. This method is estimated to represent at least 90 percent of all existing connections. Another 5 percent of the connections are "T" connections, usually selected because of cramped conditions. The remaining 5 percent of connections are direct connections into a masonry chimney.

In the heyday of gas conversions in Canada, little time was available for installers to break through up to 250 mm (10 inches) of brick work to connect a water heater directly to the chimney. Connecting the water heater to the furnace connector was the least time-consuming approach and has

therefore been adopted by habit, even though more time could be justified now for direct connections.

The most common mind set for installers is to install the furnace and then, only as an after thought, locate and install a water heater, which often results in the water heater vent connector's being quite long and circuitous.

One common approach used in newer installations is to run a vent connector from a B-vent to a water heater and, half-way in between, install a "Y" junction. The junction of the "Y" leads down through an additional elbow to the furnace. At least in this configuration, the water heater has a straight run to the B-vent. In single-storey houses, it is entirely up to the installer where the B-vent is located in the furnace room, and therefore, it is easier for the installer to optimize the location of the appliances (assuming he was appropriately informed and motivated). In two-storey houses, the location of the B-vent is usually indicated on the plans by the architect, and there is less latitude for optimizing the connection routing.

A few gas water heaters are approved for 75 mm (3 inch) vent connectors, but the majority are 100 mm (4 inch). In most cases, installers simply use 100 mm (4 inch) connectors for all the appliances.

LITERATURE REVIEW

The literature review involved reviewing articles and titles collected in a previous literature search conducted by Scanada prior to the initial development of the FLUESIM model[1]. In addition, a brief literature search was conducted at CISTI to identify any additional information that may have become available in the interim. Only one report was identified as relevant to this study -

- Consumers' Gas Chimney Venting Performance Study[2].

Review of its test results indicates that the hot water branch actually has a better ability to vent properly in adverse draft conditions than the furnace branch in shared flue venting systems. Of 34 installations tested, 29 hot water branches had a better venting ability than the furnace branch to which they were connected. On average, the hot water heater branches were able to resist 3 Pa more of house depressurization than did the furnace branches in cold vent establishment tests*

* The cold vent establishment test, it is believed, originated in the referenced project. It is a test of the appliance's ability to reverse a cold backdraft at start-up of the appliance. In this test, the house is depressurized to a large depressurization while the appliance is at standby. The flue backdrafts under these conditions. The appliance is then started up and the house depressurization is gradually lowered. Eventually the appliance reverses the backdrafting and proper venting is re-established. The house depressurization at which this re-establishing of venting occurs is called the "cold vent establishment pressure" (CVEP).

REVIEW OF CODE REQUIREMENTS

The following codes were reviewed:

Canadian Gas Association

- CAN1-B149.1-78 — INSTALLATION CODE FOR NATURAL GAS BURNING APPLIANCES AND EQUIPMENT
- CAN/CGA-B149.1-M86 — INSTALLATION CODE FOR NATURAL GAS BURNING APPLIANCES AND EQUIPMENT

National Building Code of Canada, 1985

Ontario Building Code, 1983

Proposed Changes for the 1990 edition of the National Building Code

The information gleaned from this review that is relevant to this project is as follows:

The 1986 edition of B149.1 has a new section (as compared to the 1978 edition) on "special venting systems", which deals with venting systems for intermediate and high efficiency appliances with induced draft. This section prohibits sharing of any part of the venting system serving an appliance with positive vent pressure. This change indicates an awareness by the code committee of the possibility of venting problems with shared flues.

...5.18.5 When a vent connector is required to have a size other than that of either the appliance flue collar or draft hood outlet, the change in size shall be made as follows:

(a) If the size is increased, the change in size shall be made at either the appliance flue collar or draft hood outlet...

5.18.7 A vent connector serving two or more appliances...shall have an area either:

(a) not less than the total area of all vent connectors, and the size of each individual vent connector shall be determined by 5.18.5 or,

(b) sized in accordance with an engineering table acceptable to the authority having jurisdiction.

FIELD TESTS

Sheltair Scientific Ltd. carried out tests on a number of shared flue configurations in order to provide data with which the FLUE SIMULATOR model (see below) could be calibrated. The data was also intended to provide a perspective on the theoretical findings of this study. These tests consisted of the following:

- creating three configurations of water heater vent connectors - "T", "Y" and connection at the chimney base (i.e. water heater vent connector connected to flue separately)

- measurement of a number of temperatures and flow rates for the four combinations of the following conditions:
    - furnace on or at standby;
    - water heater on or at standby

- testing each combination at various levels of house depressurization

- noting all system specifications required for FLUE SIMULATOR simulation

The system on which these tests were conducted included a masonry chimney and the furnace was connected to the chimney by a nearly horizontal vent connector with two 90° elbows. The system and the test arrangements and methods are described in more detail in Appendix A.

The test results, in the form of tables of temperatures and flows were used to calibrate the model. The complete test results are included in Appendix B.

MODIFICATIONS TO FLUE SIMULATOR

(These modifications are more fully described in the report "1st Quarter, 1987 Modifications to FLUE SIMULATOR".)

FLUE SIMULATOR is a microcomputer-based model of thermal, pressure and flow interactions in the furnace/flue/house system. It had been previously developed for CMHC by Scanada Consultants Limited and, at the start of this project, Version 3.0 was the current version.

Initial Modifications

As part of the current project, FLUE SIMULATOR was modified to be able to model shared flue systems. This involved the following changes:

- incorporation of a separate flow stream for the water heater branch and modelling of the appropriate flow interactions between the water heater and furnace streams

- modification of the code for the flow module in FLUE SIMULATOR

- modification of the energy module to account for the additional degrees of freedom of the flow system (i.e. the program must be able to deal with all of the possible flow regimes: furnace branch flow up or down, water heater branch flow up or down, main flue flow up or down)

- specification of appropriate friction loss factors for the various types of connections that can exist between the furnace branch and the water heater branch

- modification of the input routines to allow the user to specify the type and location of the connection and the water heater characteristics (The input screen is shown in Figure 1)

The flow channels which contain the energy flow and mass flow systems under investigation are depicted in Figure 2. These are the furnace vent connector branch (1-2-3-4 in the figure), and the water heater vent connector branch (1-2a-3-4). The flow equations for the furnace branch had already been defined, solved, and modelled (see Ref. 1), although a means of tying in that solution to the solution of the hot water branch was needed. The elements of the water heater branch to be modelled are the dilution port of the water heater (1-2a) and the water heater vent connector (2a-3). The portion of the vent connector downstream of the water heater connection (3-4) and upward to the top of the flue now carries both furnace and water heater streams and this must be accounted for.

DOMESTIC HOT WATER HEATER CHARACTERISTICS		
-SHARED FLUE WITH FURNACE? (Y,N)	Y	
-water heater "on" or "standby" (O,S)	S	
-burner capacity	8000.	(W)
-standby capacity (pilot light & losses)	500.	(W)
-steady state efficiency	65.	(%)
-cross-sectional area of vent connector	.0079	(m2)
-flue pipe length	1.000	(m)
-flue pipe height	.020	(m)
-number of elbows	1	
-type of connection (V,T,B)	V	
-connection:flue pipe element no.(1,2...)	2	

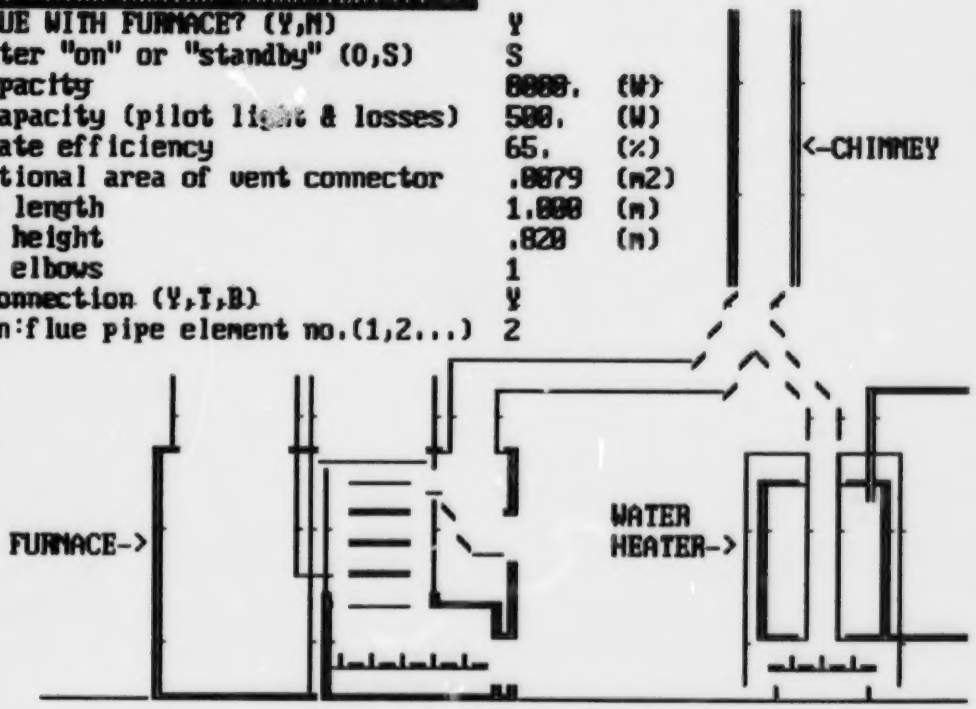


FIGURE 1: Typical user inputs for the water heater module of FLUE SIMULATOR version 4.0

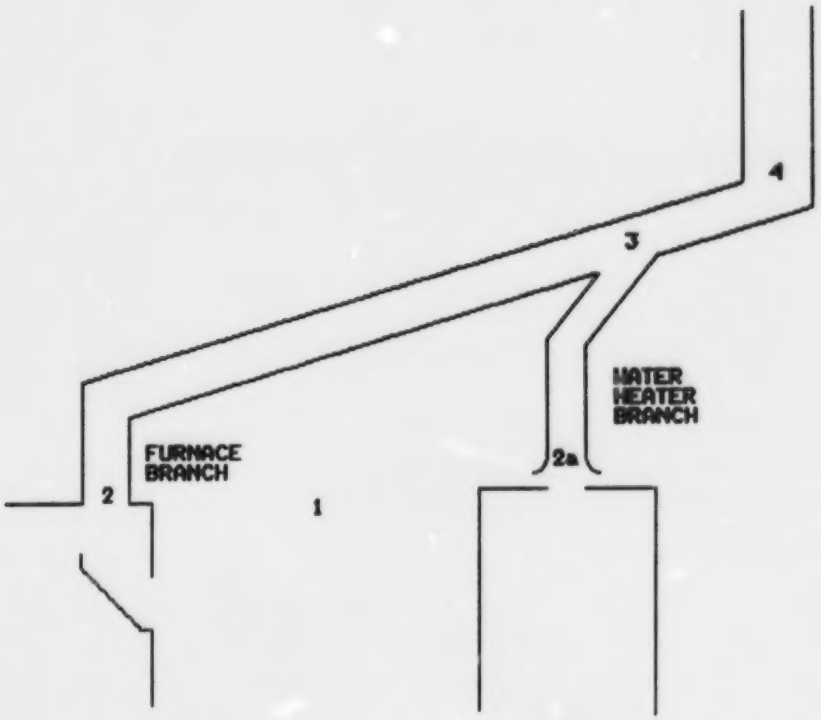


FIGURE 2: Schematic diagram of the furnace and water heater vent connectors in a shared flue arrangement

The following additional unknowns result from the addition of the water heater branch to the venting system:

- the mass flow rate of the water heater branch (which is influenced by the other unknowns)
- the friction factor at the connection of the water heater branch and the furnace branch
- the entrance, elbow, and length friction pressure losses due to the flow in the water heater branch
- the temperature rise above room temperature at the entrance of the water heater branch
- the temperature drop (or rise) between points 2a and 3 in the water heater branch.

The dynamic heat transfer performance of the water heater itself has not been modelled in this project, nor has the mass flow rate through the water heater. Rather, for this stage of the model's development, it is assumed that the water heater operates either at steady state "on" or "off" over the course of a furnace cycle. Surprisingly, this assumption allows the complete modelling of the effect of the water heater vent connector design, although not of the water heater itself. Since "steady state operation" is stipulated, the amount of heat emerging from the water heater is known from the user inputs. The flue gas temperature of the mixed stream entering the water heater branch is only a function of that energy source (heat emerging from the water heater) and the mass flow rate in the water heater connector, which the model calculates. The impact of the water heater on the performance of the furnace venting system can therefore be studied for those two modes of operation of the water heater, without having to model its dynamic performance as well. However, questions about the water heater's ability to reverse a backdraft at start-up cannot be addressed with the model as it now stands since this is a dynamic phenomenon. Thus the "cold vent establishment pressures" reported in Reference 2 can not be modelled.

Analytic Solution

The additional unknowns listed above are treated in the following fashion. The governing flow equation for the water heater branch results from the following pressure balance:

(the friction pressure drop between points 1 and 3 through the water heater branch) = (the friction pressure drop between 1 and 3 in the furnace branch) + (buoyancy of the water heater branch based on its temperature relative to that of the furnace branch)

Since the quantities on the right hand side of the equation are provided at any given time by the existing furnace branch model, and by user inputs describing the water heater heat output, the above relationship allows us to solve for flow rate in the hot water branch, once all of the friction factors of that branch are known. The friction factors for various configurations were derived by calibrating the model's predictions against the Sheltair test data, as reported in the next section.

Calibration of the Model

An initial comparison was made between the modified FLUE - SIMULATOR's predictions and the results of Sheltair Test No.4. In this test, the water heater was connected directly to the base of the chimney, the house was depressurized to 5 Pa, the water heater was on standby throughout and the furnace was started at 74 seconds and shut off at 254 seconds. Spillage from the furnace dilution port was noticed from start-up until 82 seconds - a spillage duration of 8 seconds. There was no spillage noted at the water heater dilution port.

Figure 3 is a plot of various flows as predicted by FLUE SIMULATOR. The conditions simulated are identical to the ones described above for the Sheltair Test. Note that the dilution flow is negative throughout the furnace on-time, indicating spillage duration of 180 seconds - much longer than found in the field.

The simulation of Sheltair Test No.4 was repeated several times with various modifications of the input data to indicate what changes to the model's algorithms and constants might be required. These experiments indicated that the following refinements in the model were needed:

- more accurate specification of the wind pressure coefficient and friction factor of the flue termination configuration

- refined modelling of the losses due to elbows in the vent connectors and due to the connection between the water heater branch and the chimney

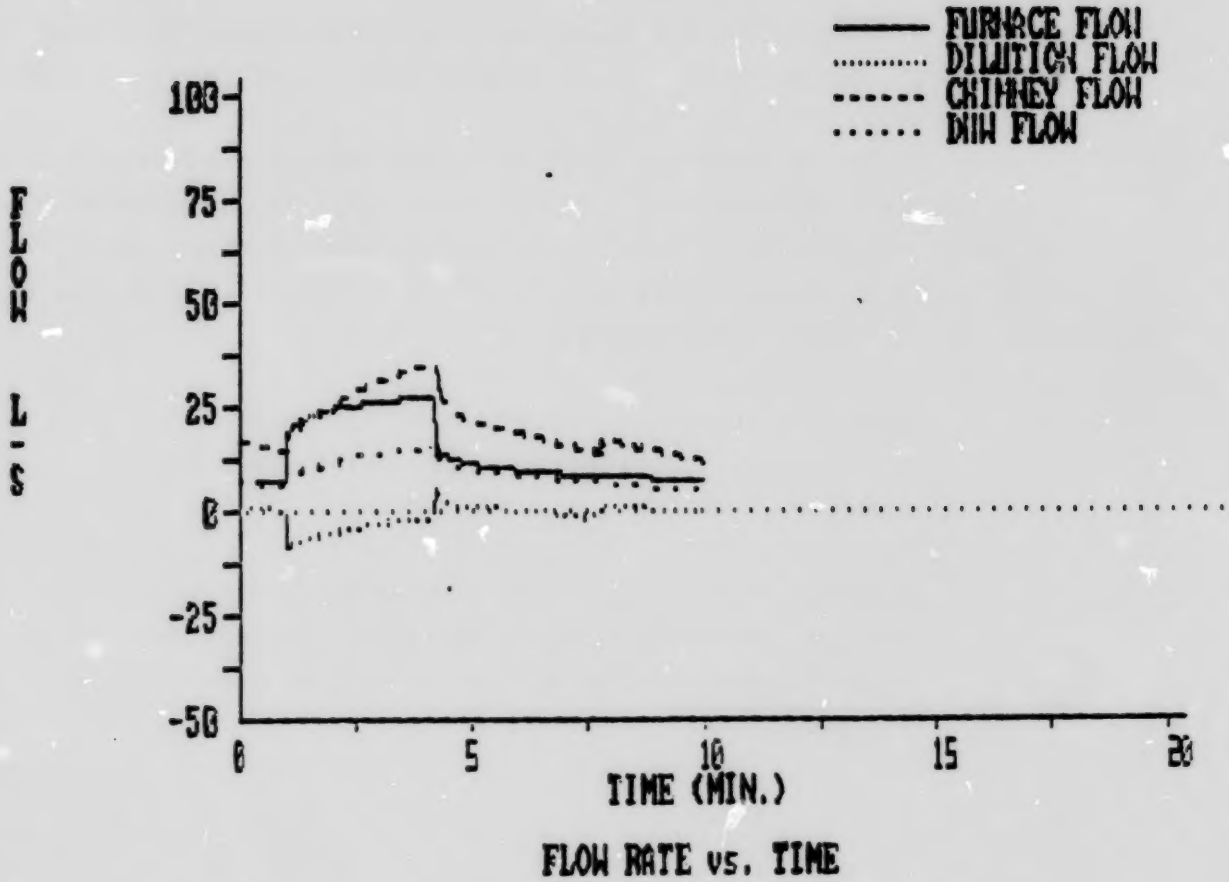


FIGURE 3: Flows predicted by modified (but not calibrated) FLUE SIMULATOR for simulation of Sheltair Test No.4

The experiments with input data also indicated that accuracy of some of the user inputs was quite critical to achieving good agreement between the model's predictions and field results. For example, the water heater standby loss input was found to have a significant effect on the model's predictions. Yet the user might have difficulty in knowing what the correct value to input would be. Previous usage history of the water heater would have a bearing on the standby heat loss - if the water heater had recently been fired, the standby loss would be greater than would be the case if it had been idle for some time. In the above comparisons, standby water heater losses up the flue varied from 100 to 400 watts.

Small variations in wind speed were also found to have a significant effect on the model's predictions.

The following refinements were made to the model:

- The proper chimney termination flow characteristics derived from laboratory tests conducted as part of another project[3] were included.

- The chimney base water heater branch connection configuration was assigned a higher friction factor, commensurate with that of a "T" connection. The fact that connection into the chimney base is downstream of the second elbow in the furnace vent connector branch was also accounted for in the model.

- The boundary layer displacement thickness algorithm used to model flow in the main flue was also used to model the water heater branch flow. This algorithm

takes into account the effect the slower moving boundary layer has in increasing the velocity of the free stream (for any given average velocity) and hence its friction loss.

Also, an addition to the FLUE SIMULATOR User's Manual was made to provide improved guidance on specification of elbows in vent connectors. Previously the user had been instructed to specify elbows in terms of the equivalent number of 45° elbows and to specify two 45° for each 90° elbow. This apparently resulted in too much friction loss. It is theorized that a second 90° elbow does not create twice as much turbulence as a single 90° elbow since the flow coming from the first elbow is already turbulent. Therefore the user is now instructed to specify two 45° elbows for the first 90° elbow and one 45° elbow for each subsequent 90° elbow.

The User's Manual also now includes guidance on specification of water heater standby losses.

Comparisons Between Test Results and Predictions of the Calibrated Model

The simulation predicted that spillage at the furnace dilution port would last 10 seconds as compared to 8 seconds measured in the field. Detailed comparisons of flow rates and temperatures predicted by the calibrated model and those measured in Sheltair Field Test #4, are shown in Figures 4 through 7. The generally good agreement between simulation and test results is a measure of the success of the calibration procedure, and reconfirms that the model simulates reality rather well.

There remains some disagreement in the prediction of chimney exit temperature as shown in Figure 7. Apparently, the model predicts too much retention of heat in the flue gases. This could be due to a number of factors. The heat transfer rate from the flue gas to the clay liner may be slightly higher in reality than predicted for the heat-up phase. For the cool-down phase, in which heat transfer rates are lower and in the other direction (from liner to the flue gas stream), the model appears to be simulating very accurately. An alternate explanation for the lower measured exit temperatures may be that there is outdoor air leakage into the masonry chimney during heat-up when strong buoyant forces would induce this leakage downstream of the vent connectors. Chimney leakage is not yet modelled in FLUE SIMULATOR and is not easily measured in the field. However, except for unusually leaky chimneys, it would appear that the model can be used with some confidence to investigate the role of various parameters of the venting system.

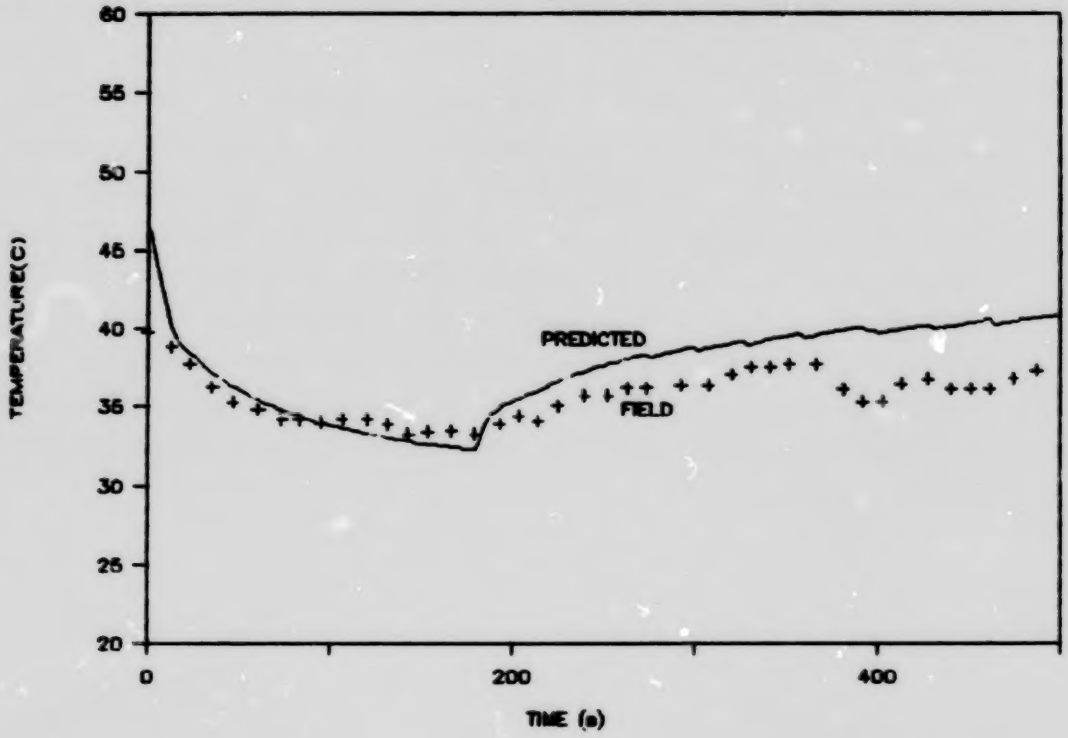


FIGURE 4: Comparison of measured and predicted temperatures in the water heater vent connector branch (0.2m downstream of water heater draft hood)

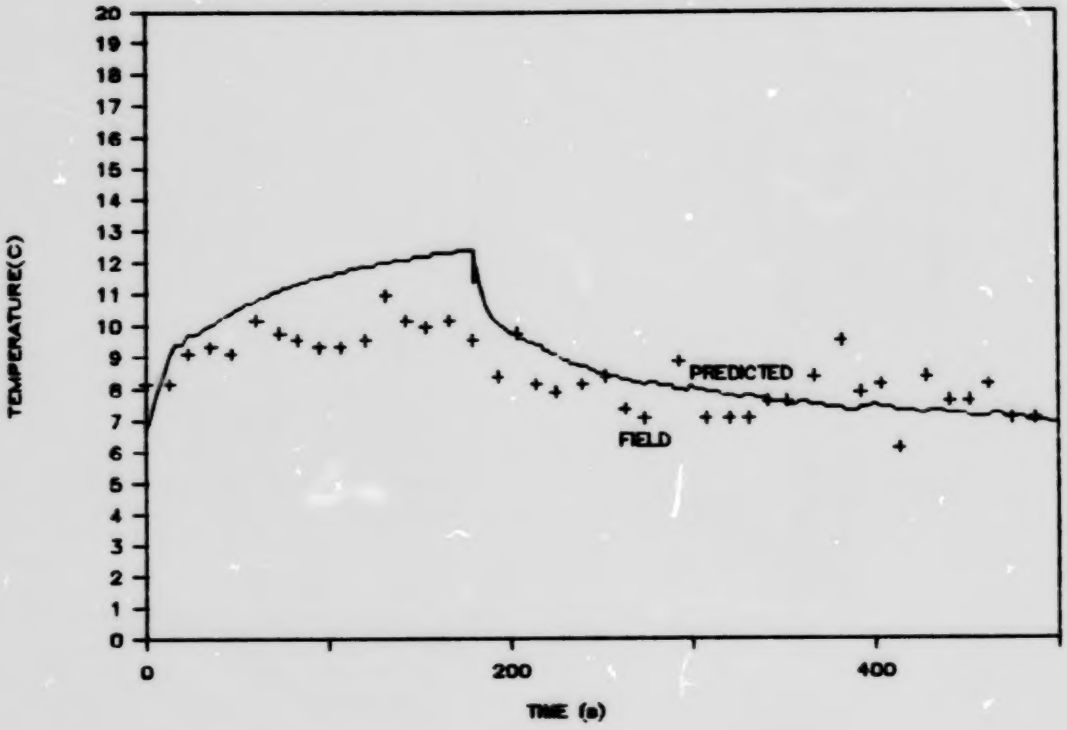


FIGURE 5: Comparison of measured and predicted flows rates in the water heater branch (0.2m downstream of water heater draft hood)

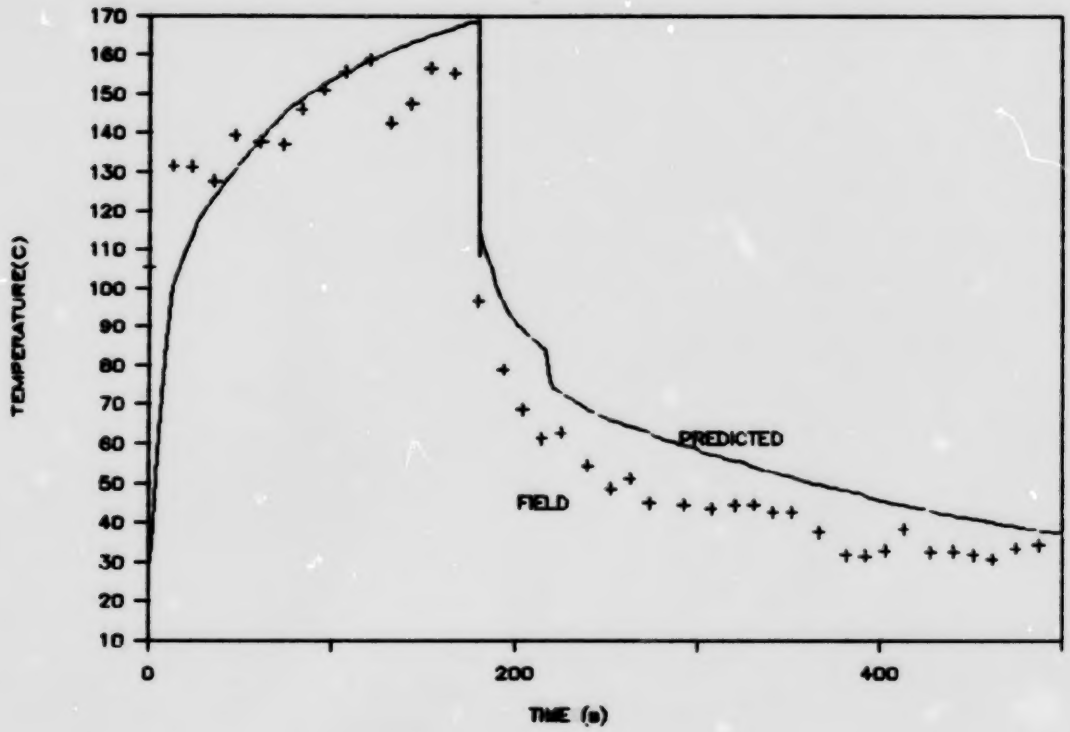


FIGURE 6: Comparison of measured and predicted gas temperatures in the furnace vent connector (0.3m downstream of furnace dilution port)

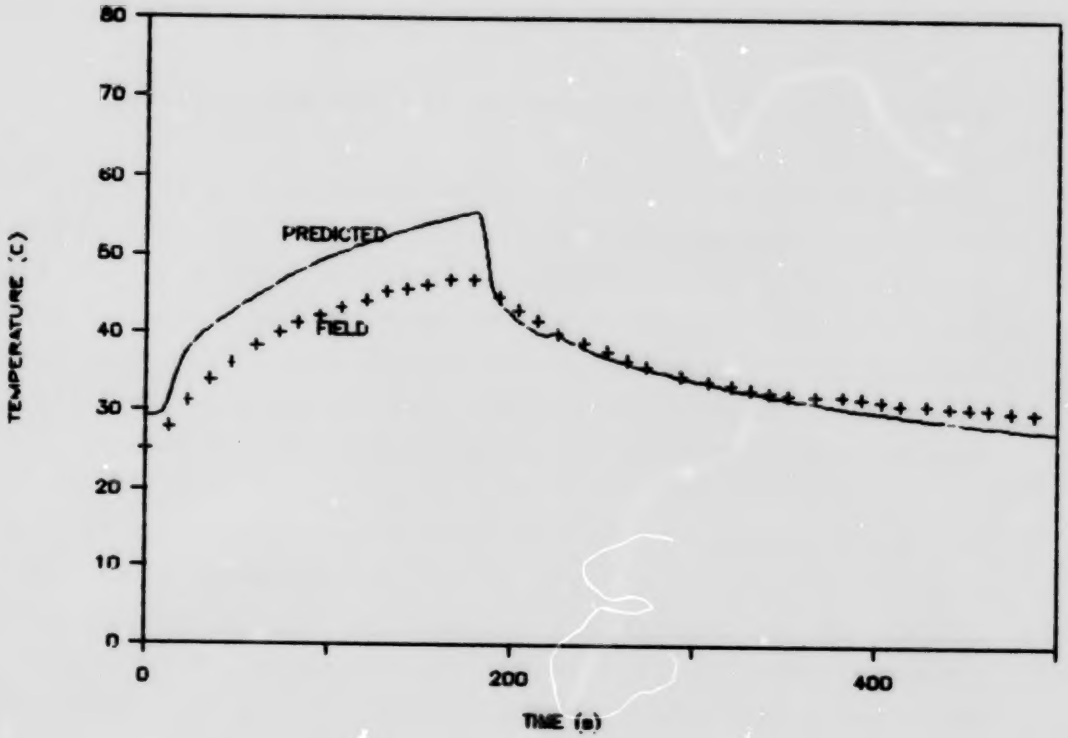


FIGURE 7: Comparison of measured and predicted gas temperatures at the chimney exit.

PARAMETRIC STUDY

It is presumed that general rules developed for proper operation of a venting system serving a single appliance largely apply to a two-appliance venting system. This parametric study has therefore focussed primarily on the interaction of the water heater vent connector with the furnace vent connector. The objective of this work was to highlight which parameters affect this interaction and to what extent these should be considered in the design.

Effect of Driving Pressures of the Hot Water Branch

In the pressure balance equation presented on Page 14, two driving pressures that affect the flow in the water heater branch are implied. Both involve the characteristics of the furnace branch as well as those of the water heater branch. These are the **net buoyancy** of the water heater branch relative to that of the furnace branch and the **induced pressure** in the water heater branch resulting from the flow in the furnace branch.

The **net buoyancy** of the hot water branch is the difference in pressure acting on the gas in the water heater branch due to the difference in temperature between it and the furnace branch. (The net buoyancy is a result of the summation of column weights along path 1-2-3-2a-1 in Figure 2.) If the hot water branch is hotter than the furnace branch then the buoyancy is positive and vice versa.

The induced pressure is the pressure drop in the water heater branch induced by the friction losses of the flow through the furnace dilution port and the furnace branch from the dilution port to the connection of the water heater branch. (The induced pressure is a result of friction pressure drop along path 1-2-3 in Figure 2.) The greater the flow in the furnace branch or the

smaller the equivalent flow area* (EFA) of that branch, the greater the friction pressure drop between dilution port and the connection, and the greater the **induced pressure** acting on the water heater flue gas in the connector. The summation of these two pressures determines which direction the hot water branch flows.

Figure 8 shows a simulation of the typical behaviour of the water heater branch buoyancy and induced pressure when the water heater is at standby and the furnace cycles through a heat-up (5 min.) and cool-down (15 min.) phase. There is no house depressurization in this example. Also shown on the graph, as points of reference, are the chimney/house buoyancy (i.e. theoretical draft of the chimney less the house buoyancy) and the furnace buoyancy.

The water heater branch buoyancy and induced pressure almost form mirror images of one another about the zero pressure line. The induced pressure is positive and slightly greater than the buoyancy pressure which is negative through most of the cycle (i.e. the furnace branch is hotter than the water heater branch, up to about the 15 minute mark). As the summation of these two is positive, the air in the water heater branch flows upward throughout the furnace cycle. However, because changes in the two pressures tend to cancel, the rate of flow through the water heater branch is moderated and does not follow the large changes occurring in the flow rate of the furnace branch.

This simple graph also highlights a key feature of the balance between the water heater branch and the furnace branch. If the

* The equivalent flow area of a vent connector is the area of sharp-edged orifice that would pass the same flow as the vent connector at any given pressure difference.

EFA of the furnace branch were large - e.g. large vent connector and few or no elbows - then the induced pressure across the water heater branch might be reduced to a point where it would be algebraically smaller than the buoyancy term. With such a design, the furnace gas could spill down the water heater branch at start-up under low draft conditions. This would be especially problematic if the rest of the chimney had a small EFA (e.g. chimney blockage, restrictive cap) since this would minimize the flow rate in the furnace branch and thus reduce the induced pressure even more.

Figure 9 shows the buoyancy and induced pressures for the water heater branch when the water heater is at steady state operation. Here both driving pressures are positive so that the water heater branch will flow upward throughout the cycle. The chimney buoyancy is of course increased due to the two simultaneous sources of energy. This highlights the fact that a shared flue statistically has a better chance of avoiding chimney standby backdrafting than a flue serving a single appliance since there are fewer occasions when the chimney is at full standby.

Finally, it will be noted that, for the system simulated, the water heater branch buoyancy approaches zero when the furnace approaches steady state. This is a sign of a well balanced venting system in that the gas temperatures are approximately the same in both branches at steady state operation. The same can be said of the buoyancy for steady state "off" conditions shown at the 20 minute mark in Figure 8.

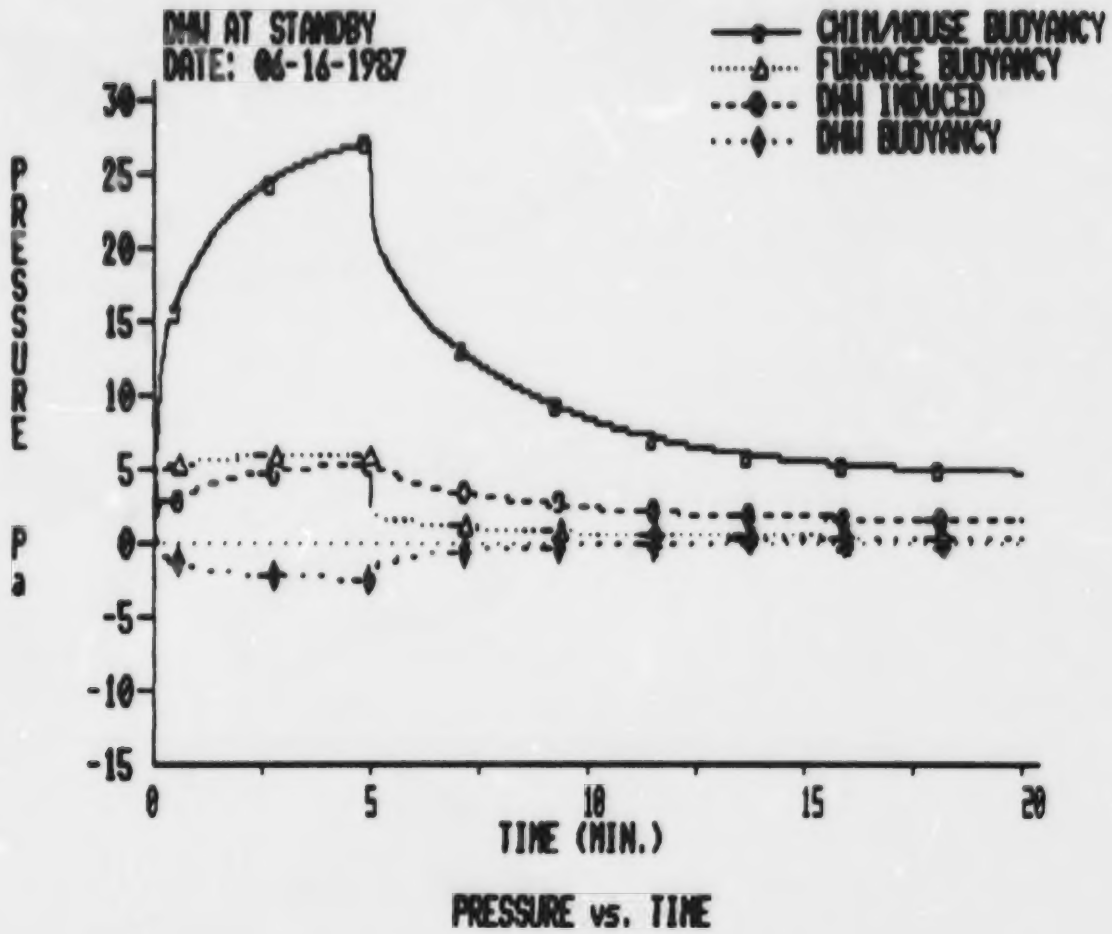
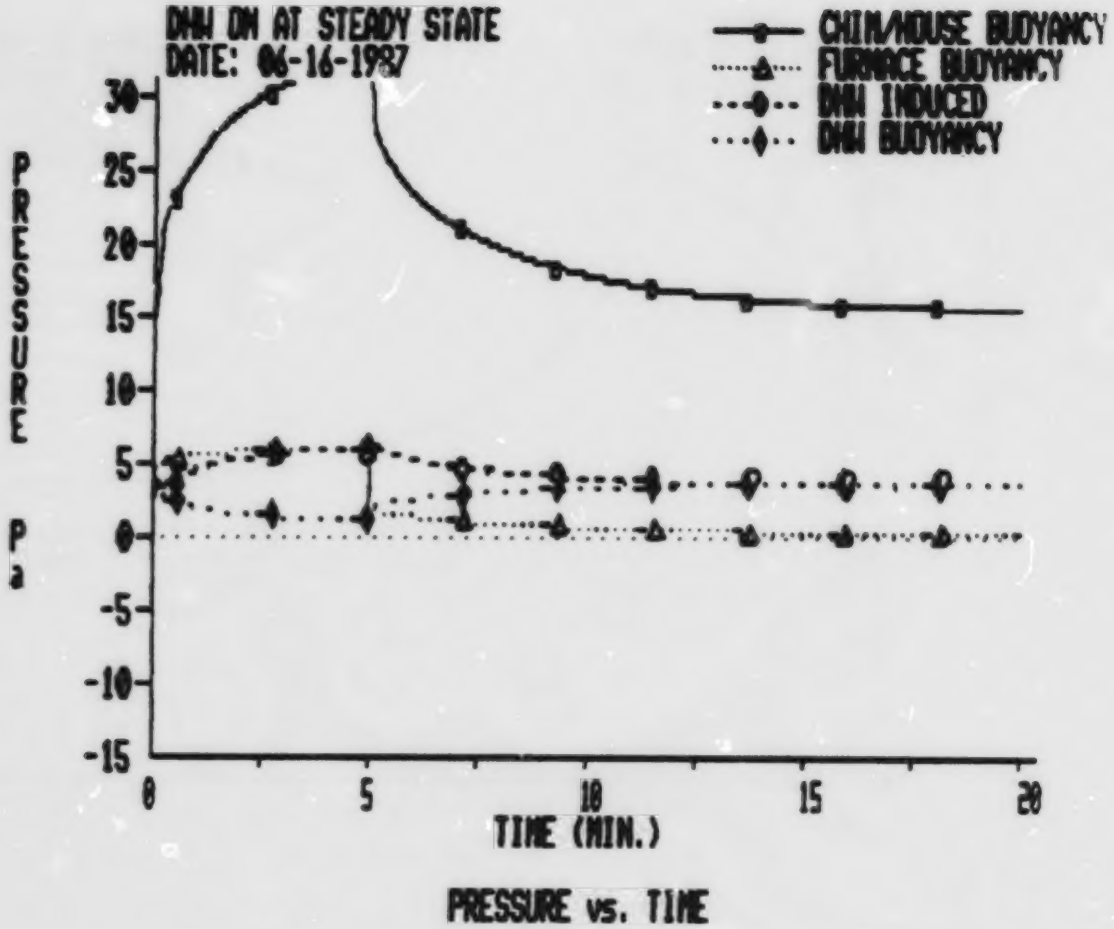


FIGURE 8: Predicted pressure in a shared flue system - water heater at standby



PRESSURE vs. TIME

FIGURE 9: Predicted pressure in a shared flue system - water heater at full operation

Effect of Relationship Between Branch EFA's

A number of simulations where undertaken to illustrate the relationship between the equivalent flow areas of the water heater and furnace branches and their venting performance. These were done for an installation operating near the depressurization limit, where a balanced design becomes critical for proper venting of both appliances. The simulations consisted of starting up a gas furnace at low draft (i.e. with the house depressurized), while maintaining the water heater at standby. The durations of spillage of the furnace combustion gases were noted and are reported in Table 1.

TABLE 1. Effect of vent connector EFA's on the duration of furnace start-up spillage at the furnace dilution port for low draft conditions with the water heater is at standby.

Case #	WATER HEATER BRANCH EFA (cm2)	FURNACE BRANCH EFA(cm2)	RATIO (-)	SPILLAGE DURATION(s)
REF.	0 (none)	138	--	38
1	78	138	.57	111
2	78	154	.51	78
3	72	154	.47	73

The Reference Case has no water heater. The duration of combustion gas spillage at the furnace dilution port is typical for a low draft start-up (house depressurized to 5 Pa) on a furnace connected to a nearly horizontal vent connector with two 90° elbows. Connecting a water heater to this venting system has a dramatic effect on the duration of combustion gas spillage at the

furnace, when the water heater is at standby. (The spillage occurring at the water heater port is unknown because the water heater flow rate per se is not modelled; however this spillage quantity is somewhat irrelevant when the water heater is at standby). The tripling of the duration of spillage at the furnace dilution port is explained by the fact that connecting the water heater vent connector into the furnace vent connector is equivalent to opening a rather large leak in the furnace vent connector. This greatly reduces draft upstream of the connection, which, in turn, reduces the rate at which the flow out of the furnace heat exchanger is drawn away. Since the furnace flow is undiminished, more of that flow must spill out the dilution port. A secondary effect is that, because more of the flue gas is spilling into the house and less is going up the chimney, the chimney heats up more slowly and thus its draft increases more slowly. Both the diminished furnace vent connector flow and the slower heating of the chimney contribute to the increased duration of spillage. Figure 10 shows the furnace and venting system flow rates 25 seconds after furnace start-up for both the Reference Case and for Case 1. Note that the chimney flow in Case 1 is higher although the furnace vent connector flow is lower. The furnace is needlessly venting the essentially clean air from the water heater dilution port - the water heater being at standby - while more flue gases from the furnace spill into the house.

It is also interesting to note that the water heater connection at standby is much like a large leak in the venting system. In fact, large leaks would have an even worse effect on spillage duration since no standby heat is associated with these. The

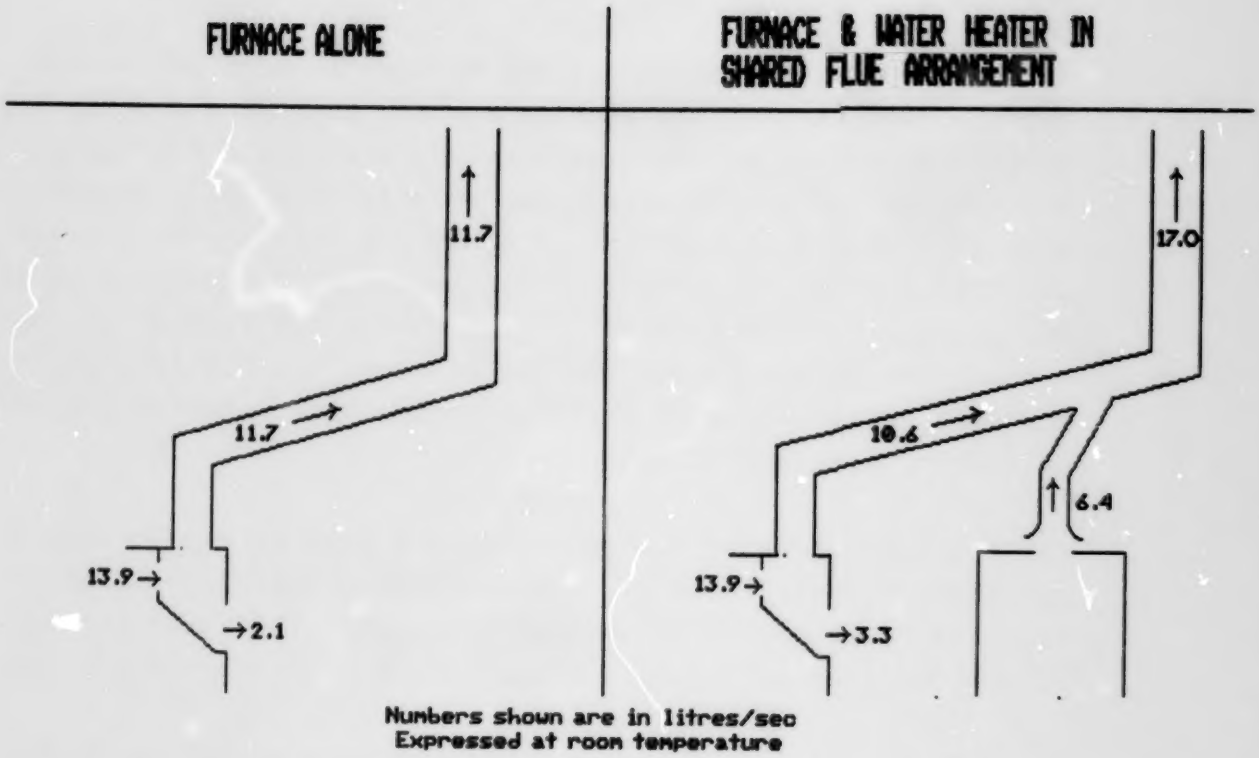


FIGURE 10: **Flow rates in the venting system 25 seconds after furnace start-up (5 Pa house depressurization)**

effect of leakage in the venting system has been reported by Sheltair for some time, based on field results, but the above results represent the first analytic quantification of that effect.

In cases where the venting of the furnace is marginal with a water heater sharing the venting system, there are a number of options available to minimize start-up spillage. For example the furnace vent connector branch can be made "cleaner", in the fluid mechanics sense, by removing an elbow and effectively increasing the EFA of that connection. The increase in furnace branch EFA from Case 1 to Case 2 in Table 1 is due to the removal of one 45° elbow. Comparison of the results of Cases 1 and 2 indicates the strong helpful effect of increasing the EFA of the furnace branch on furnace spillage duration.

The decrease in water heater branch EFA from Case 2 to Case 3 is due to an added 45° elbow. The decrease in spillage duration from Case 2 to Case 3 shows that <u>decreasing</u> the water heater branch EFA also helps the furnace branch, but only marginally.

The reduced spillage duration due to reduced water branch EFA confirms that the water branch acts as an effective additional leak in the venting system which taxes the venting ability of the other branch. However, as the water heater branch EFA is reduced, the amount of dilution flow entering the water heater branch is reduced and the temperature of the gas in this branch therefore increases. This increases its buoyancy, which makes it compete more with the furnace branch. Hence the overall effect of changing the EFA of the water heater branch on the performance of the furnace branch is small.

Furthermore, there are limits to decreasing the EFA of the water heater branch dictated by the proper venting of the water heater

when it is in operation. This suggests that there exists an optimum combination of branch EFA's that will minimize spillage from both branches. Finding that optimum is beyond the scope of this study since it requires the dynamic modelling of the water heater, which FLUE SIMULATOR is not yet capable of doing.

The strong effect of changes in the furnace branch EFA is explained by the fact that the vent connector of the above example represents the major resistance in that particular venting system. The furnace vent connector is connected to an oversized masonry chimney which offers little flow resistance at start-up.

Effect of Type of Connection

Three types of connections between water heater and furnace vent connectors where investigated using the model and field data generated for this study:

- a typical "Y" type connection (the Reference Case),
- a "T" connection, and
- the connection of both branches separately into the base of the chimney.

The approach followed in this portion of the investigation was to attempt to match the simulations to field results by specifying appropriate friction factors for the three types of connections investigated. This approach resulted in realistic (field validated) friction loss factors being specified for each connection type. It also furthered the validation process of the overall model and highlighted problem areas in the original modelling of the water heater branch and its connection.

Graphs of predicted and measured flow rates through the water heater branch for a heat-up/cool-down cycle of the furnace are shown in Figures 11, 12 and 13, for the "Y", "T", and "base of

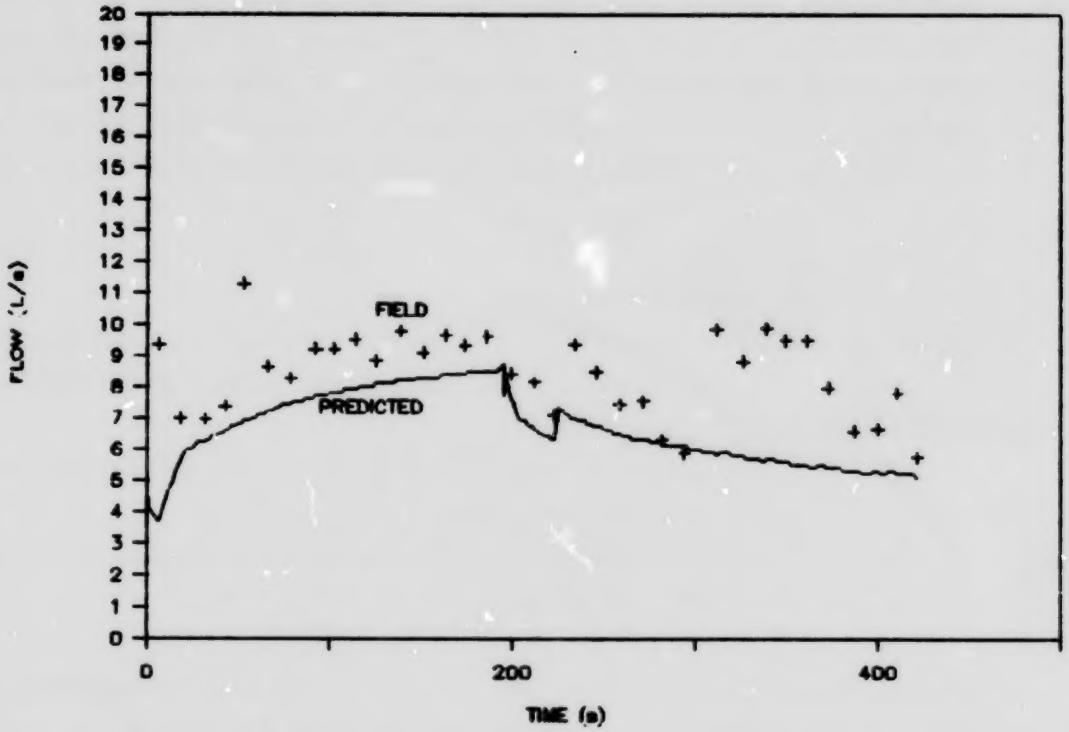


FIGURE 11: Comparison of measured and predicted flows in the water heater vent connector branch - "Y" connection

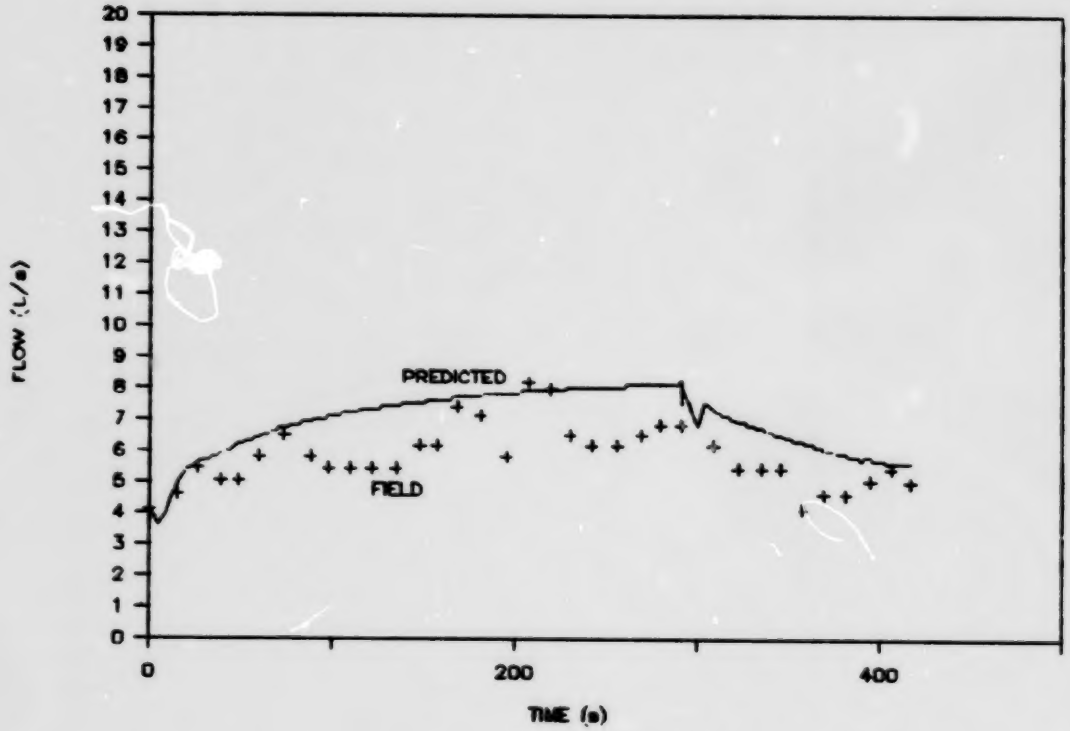


FIGURE 12: Comparison of measured and predicted flows in the water heater vent connector branch - "T" connection

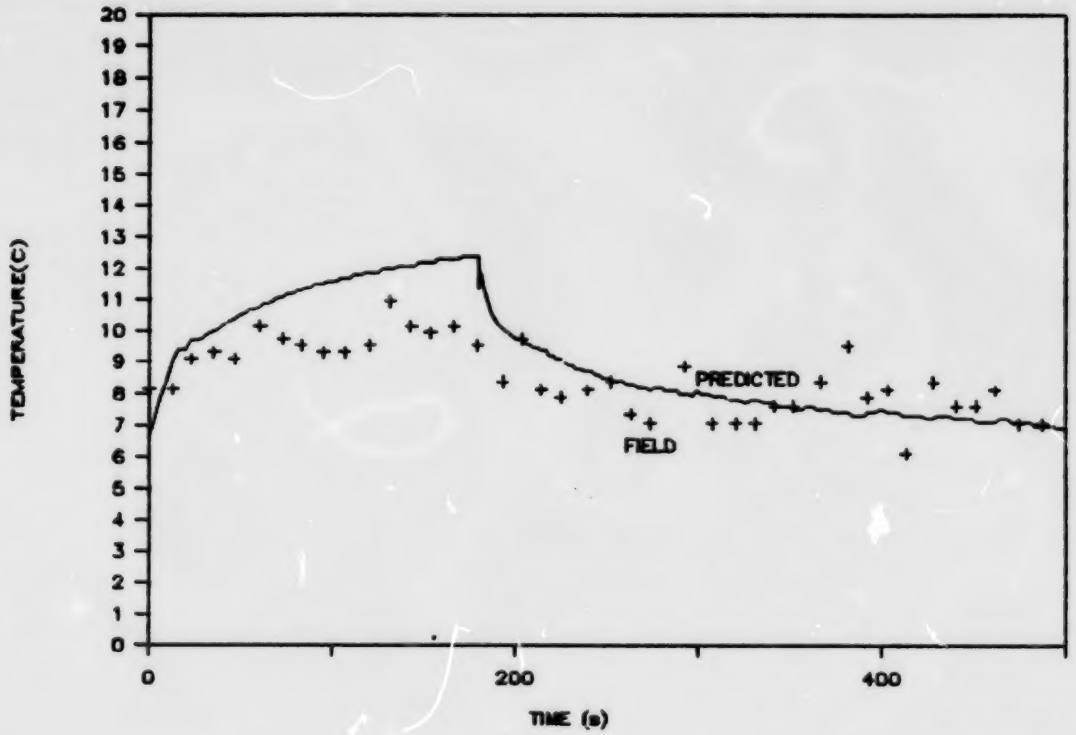


FIGURE 13: Comparison of measured and predicted flows in the water heater vent connector branch - "Base" connection

chimney" connections respectively. (Figure 13 is a repeat of Figure 5, for the convenience of the reader.) The match between simulation and measurement is quite good in all three cases. The friction factor results, shown in the Table 2 below, are dramatic - the "Y" connection is clearly the better design in that it presents the least resistance to flow in the water heater branch. The connection into the base of the chimney is effectively a "T" connection.

However, ranking the connections by friction factor alone is misleading in that there are other factors which affect the flows. Although the "Y" connection is aerodynamically superior to both the "T" and "Base" connections, the connection at the base of the chimney resulted in 50% more water heater branch flow than was obtained with the "Y" and "T" connection, as shown in Table 2. Moreover, the furnace branch also experienced a higher flow rate when the water heater branch connection was into the base of the chimney (furnace branch flows not shown).

TABLE 2. Friction factors of the connection between the water heater branch and the furnace branch (deduced by matching the simulation to field data)

	FRICTION FACTOR	PREDICTED WATER HEATER BRANCH FLOW AT FURNACE SHUT OFF (L/s)
"Y" CONNECTION	1.5	8.5
"T" CONNECTION	2.5	8.1
"BASE OF CHIMNEY"	2.5	12.4

This is explained by two factors - both overlooked in the original modelling of the water heater branch and both of which

had to be included to match the data. First, the water heater connection to the base of the chimney is **downstream of both elbows** in the furnace branch; this results in greater induced pressure acting on the water heater branch. Second, the "Y" and "T" junctions are **upstream of the expansion** in the flow path that usually occurs at the junction of the vent connector and the masonry chimney. This means that the shared portion of the vent connector (i.e. that portion that lies between the water heater branch connection to the furnace branch and the latter's connection to the chimney) has to carry both furnace and water heater flows. Even if it has been sized for this combined flow, the vent connector is usually smaller and thus more restricting than the flue itself. This suggests that if the flow area in the flue is greater than that of the furnace vent connector, connecting the water heater branch directly into the chimney would result in less restriction of the flows in both branches and thus would result in less interference between the branch flows. Where the main flue is not significantly larger than the furnace vent connector, there will be no benefit to this configuration and the "Y" connection may be preferable due to its low friction factor.

Effect of Characteristic Length of Each Branch

The characteristic length of the vent connector branches - as defined by J.H. White in "Chimney Thermal Characteristics for Effective Venting" January 1986 - is a measure of the ability of the connector to transport heat up the flow path without losing it on the way. Expressed as length of connector or pipe, it is the length of flue along which the flue gas will loose 2/3 of its heat.

The characteristic length is defined by White as follows:

$$L^* = \frac{\rho C_p R_f Q}{C_{sf}}$$

where: L^* = characteristic length of the flue pipe (m)

ρ = density of the gas in the flue pipe (kg/m^3)

C_p = heat capacity of the gas in the flue pipe (w.s/kg°C)

R = heat loss resistance of the flue pipe (m^2°C/w)

Q = flue gas flow rate (m^3/s)

C_{sf}= inner circumference of the flue pipe (m)

The longer the characteristic length, the farther along the connector the flue gas can maintain most of its energy and thus buoyancy. Because the characteristic length is a function of flow rate as well as degree of insulation of the connector wall, this quantity varies throughout the cycle of operation of the appliances. Figure 14 shows how the characteristic lengths of the two vent connector branches vary over a furnace heat-up/cool-down cycle with the water heater at standby. As the flow rates increase in both branches following furnace turn on, the characteristic lengths increase. The jump in length just after furnace shut down reflects the sudden change in density of the air in the flue (colder room air) and has little importance to the problem. Of note is the range in characteristic lengths over the cycle - 4 to 8 meters for the furnace branch, and 3 to 4 meters for the water branch. Actual connector lengths should be considerably smaller than these to maintain the temperatures of the gas passing through as much as possible and thus maintain draft.

Figure 15 shows the profiles of characteristic lengths of both branches when the furnace is run through a full cycle with the house depressurized to its depressurization limit. The water

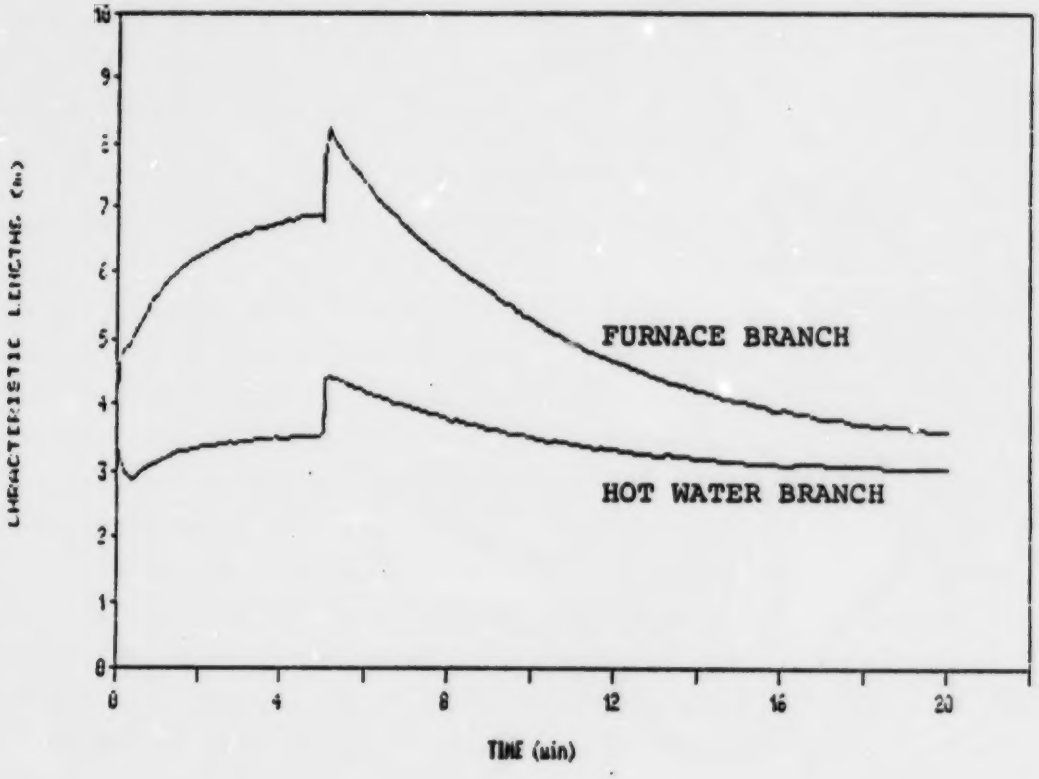


Figure 14: Variation of typical characteristic lengths of vent connectors over a heat-up/cool down cycle of the furnace - no house depressurization, water heater at standby.

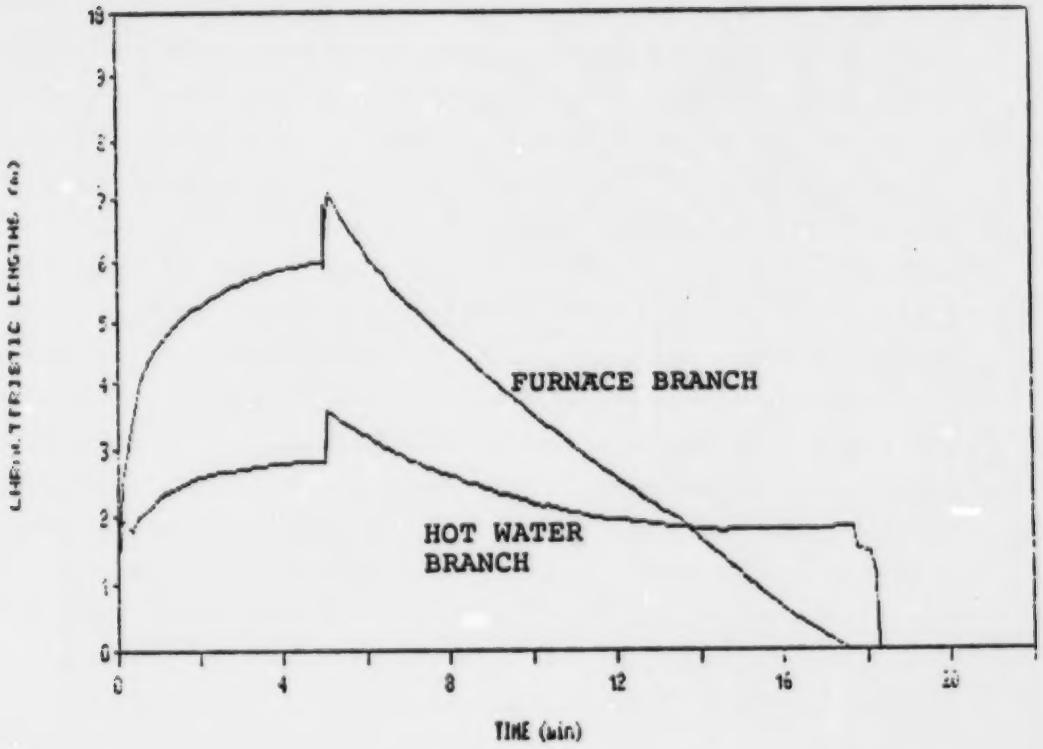


Figure 15: Variation of typical characteristic lengths of vent connectors over a heat-up/cool down cycle of the furnace - house depressurized to its depressurization limit, water heater at standby.

heater is again at standby. The characteristic lengths of both branches are now lower than in the previous figure throughout the cycle. This means that under difficult venting conditions, the thermal design of the connectors becomes more critical. At about 14 minutes, the flow in the furnace branch begins to stall and the characteristic length goes through zero to negative values (i.e. backdrafting). The falling characteristic lengths of the furnace branch are both a symptom and, at least in part, the cause of the problem at this stage. The flow is so slow in the furnace connector branch that the characteristic length falls below the actual length of the connector. Its ability to maintain draft in itself, and to supply the chimney with hot gases is lost. The water heater branch is able to maintain its characteristic length up until a full backdraft reverses the flow in this branch as well. The furnace branch is thus identified as the weak link in this low draft situation. This difference in branch performance is likely due to the larger diameter (and hence larger surface area) of the furnace connector, its longer actual length, and the fact that less standby heat is coming from the furnace than is being supplied to the water heater branch by the water heater. A possible improvement to the system might be double lining of the furnace branch.

GUIDELINES

Guidelines on the specification and installation of water heater branches for shared flue configurations are provided in "Remedial Measures for Houses with Chimney Spillage Problems - A Guide for Contractors and Tradesmen."

CONCLUSIONS

The results of this study indicate that the sharing of flues greatly exacerbates venting problems when the conditions for proper venting are already adverse. This makes it important that both the furnace and the water heater vent connectors have "clean" flow areas with as few elbows and contractions as possible. As well, it was shown that the flow area of the venting system downstream of the connection of the furnace and water heater vent connectors should also be as "clean" as possible. This has implications on flue cap design and sizing of the main flue.

Field and modelling results were used to suggest how well various current practices in vent connector installation serve the above design objectives. It was found that configurations in which the water heater vent connector is connected separately to the flue (i.e. it does not connect to the furnace vent connector) should be the least prone to combustion venting problems. In cases where connection of the water heater branch to the furnace vent connector is unavoidable, the "Y" connection was shown to introduce less friction and therefore would be less prone to combustion venting problems than the "T" connection.

REFERENCES

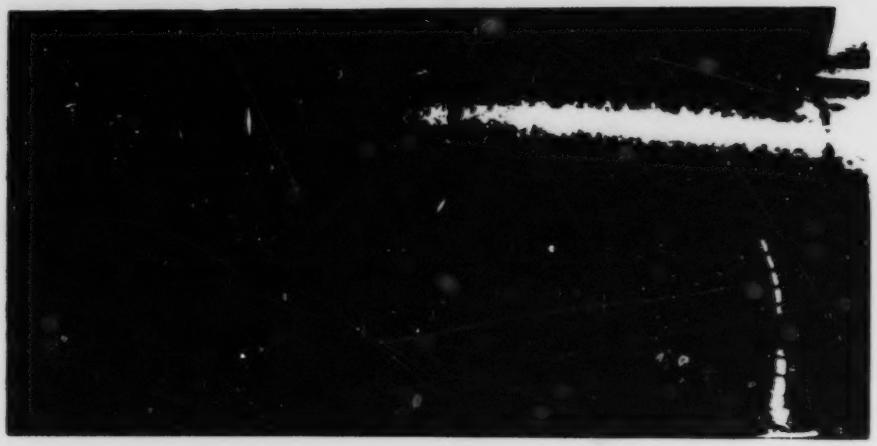
1. The thermal and flow performance of furnace flues in houses. Prepared for Canada Mortgage and Housing Corporation by Scanada Consultants Limited, March 1985.

2. Consumers' Gas Chimney Venting Performance Study. Prepared by the Centre for Building Science, University of Toronto for BETT, EMR, and the Ontario Ministry of Energy, 1986.

3. The influence of termination configuration on the flow performance of flues. Prepared for Canada Mortgage and Housing Corporation by Scanada Consultants Limited, March 1987.

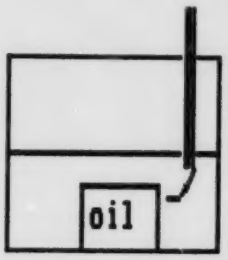
APPENDIX A

TEST SET UP FOR THE VARIOUS WATER HEATER CONNECTIONS

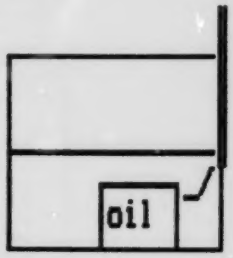


FUEL TYPE AND CHIMNEY LOCATION SELECTION

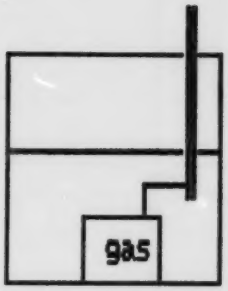
#1-Oil Furnace With Interior Chimney



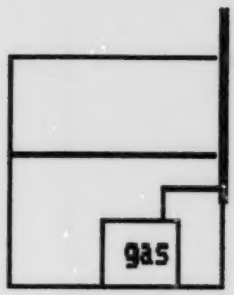
#2-Oil Furnace With Exterior Chimney



#3-Gas Furnace With Interior Chimney

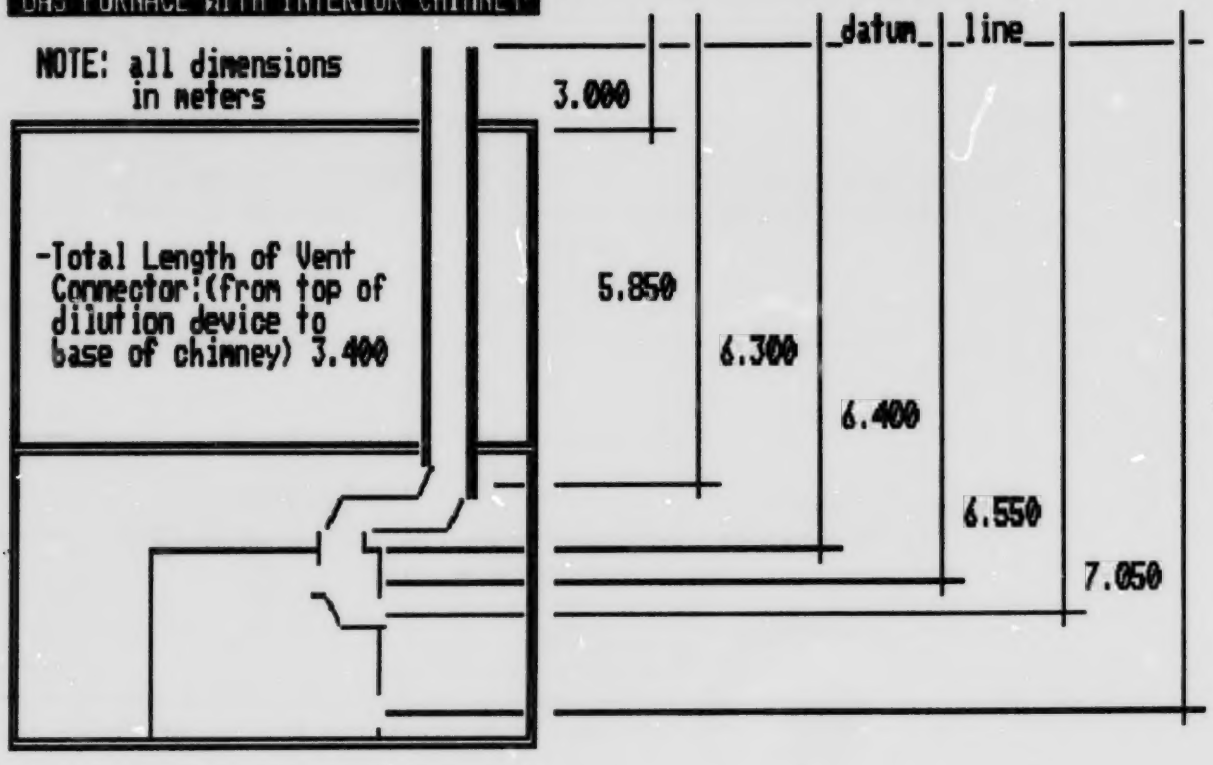


#4-Gas Furnace With Exterior Chimney



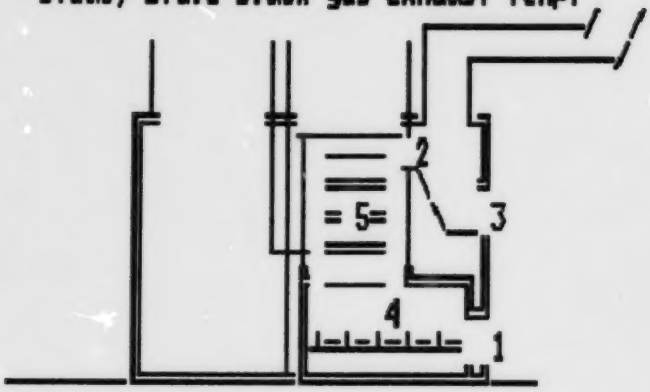
ENTER YOUR SELECTION #(1,2,3 or 4): 3

GAS FURNACE WITH INTERIOR CHIMNEY



GAS FURNACE CHARACTERISTICS

OPENING AREAS:	-1-combustion air inlet	.0305	(m2)
	-2-outlet (breech)	.0195	(m2)
	-3-draft hood opening area	.0351	(m2)
OTHER DATA:	-4-interior chamber volume	.025	(m3)
	-5-heat exchanger's:-mass	35.0	(kg)
	-heat capacity	500.	(W.s/kg.C)
	-firing rates-full on	29300.	(W)
	-standby(pilot light)	300.	(W)
	-steady state efficiency	77.0	(%)
	-steady state stack gas exhaust temp.	260.0	(C)



FLUE PIPE CHARACTERISITCS

TOTAL NUMBER OF STRAIGHT SECTIONS FROM TOP OF DILUTION DEVICE TO CHIMNEY BOTTOM

INPUT NUMBER OF SEGMENTS

DEFAULT VALUE IS 3

INPUT YOUR SELECTION -> ? 3

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

HOW MANY 45 deg. ELBOWS IN THE FLUE PIPE OR VENT CONNECTOR

(ENTER 2 FOR EACH 90 deg. ELBOW. ADD 2.5 FOR A TEE SECTION)

DEFAULT VALUE IS 4

INPUT YOUR SELECTION -> ? 4

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 1

INPUT THE RISE OF THIS SECTION(in m)

DEFAULT VALUE IS 0.41000

INPUT YOUR SELECTION -> ? 0.41000

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 1

INPUT THE LENGTH OF THIS SECTION(in m)

DEFAULT VALUE IS 0.41000

INPUT YOUR SELECTION -> ? 0.41000

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 2

INPUT THE RISE OF THIS SECTION(in m)

DEFAULT VALUE IS 0

INPUT YOUR SELECTION -> ? 0

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 2

INPUT THE LENGTH OF THIS SECTION(in m)

DEFAULT VALUE IS 2.70000

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 3

INPUT THE RISE OF THIS SECTION(in m)

DEFAULT VALUE IS 0

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE CHARACTERISITCS

SECTION 3

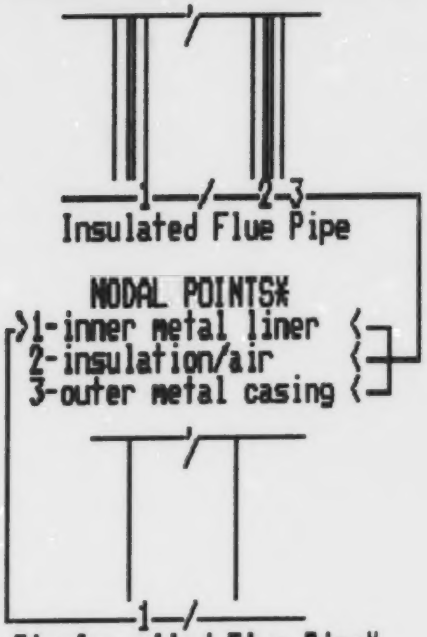
INPUT THE LENGTH OF THIS SECTION(in m)

DEFAULT VALUE IS 0.24000

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

FLUE PIPE / VENT CONNECTOR



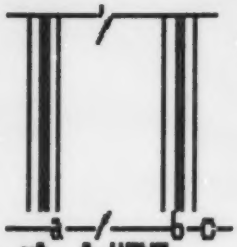
Open Area of the Flue Pipe	.0133	(m2)
Circumference or Perimeter		
1-inner metal liner	.408	(m)
2-insulation	0.000	(m)
3-outer metal casing	0.000	(m)
Element Thickness		
1-inner metal liner	.0003	(m)
2-insulation	0.0000	(m)
3-outer metal casing	0.0000	(m)
Densities		
1-inner metal liner	7830.0	(kg/m3)
2-insulation	0.00	(kg/m3)
3-outer metal casing	0.0	(kg/m3)
Heat Capacities		
1-inner metal liner	500.0	(W.s/kg.C)
2-insulation	0.0	(W.s/kg.C)
3-outer metal casing	0.0	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	8.30	(W/m2.C)
-points 2 and 3	0.00	(W/m2.C)
-points 3 and surrounding	0.00	(W/m2.C)

*For single walled flue pipe enter "0" for all entries of nodal points 2 & 3.

CHIMNEY TYPES

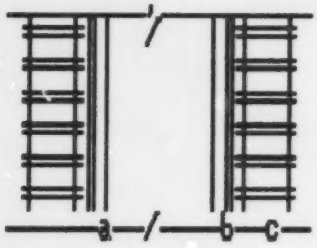
STUDY THE FOUR CHIMNEY SECTIONS BELOW AND SELECT THE TYPE THAT BEST DESCRIBES THE CHIMNEY YOU WANT TO MODEL

#1 MASONRY
a-clay flue liner
b-air space
c-masonry enclosure



#2 A-VENT
a-inner metal liner
b-insulated cavity
c-outer metal casing

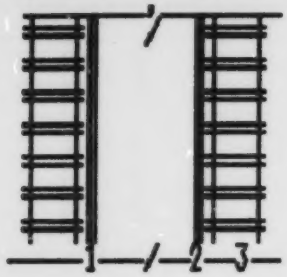
#3 B-VENT
a-inner metal liner
b-outer metal casing
c-enclosing structure



4 MASONRY WITH METAL FLUE LINER
a-metal flue liner
b-clay flue liner
c-masonry enclosure

ENTER YOUR SELECTED CHIMNEY TYPE #1

MASONRY CHIMNEY CHARACTERISTICS



NODAL POINTS
1-inner half of clay liner
2-outer half of clay liner
3-masonry enclosure
(brick or other
masonry products)

Open Area of the Flue	.0446	(m2)
Circumference or Perimeter		
1-inner half of liner	.870	(m)
2-outer half of liner	1.046	(m)
3-masonry enclosure	1.438	(m)
Element Thickness		
1-inner half of liner	.0110	(m)
2-outer half of liner	.0110	(m)
3-masonry enclosure	.0980	(m)
Densities		
1-inner half of liner	1790.0	(kg/m3)
2-outer half of liner	1790.0	(kg/m3)
3-masonry enclosure	1970.0	(kg/m3)
Heat Capacities		
1-inner half of liner	829.0	(W.s/kg.C)
2-outer half of liner	829.0	(W.s/kg.C)
3-masonry enclosure	800.0	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	91.00	(W/m2.C)
-points 2 and 3	47.20	(W/m2.C)
-points 3 and surrounding	5.26	(W/m2.C)

ENVELOPE

Airtightness Characteristics: (as defined by standard CAN/CGSB-149.10-M)	-flow coefficient: C	.11800	(m3/s.Pa^n)
	-flow exponent: n (non dimensional)	.670	
Maximum Exhaust Fan Flow Rate:		350.0	(L/s)
Maximum Fireplace Flow Rate:		0.0	(L/s)

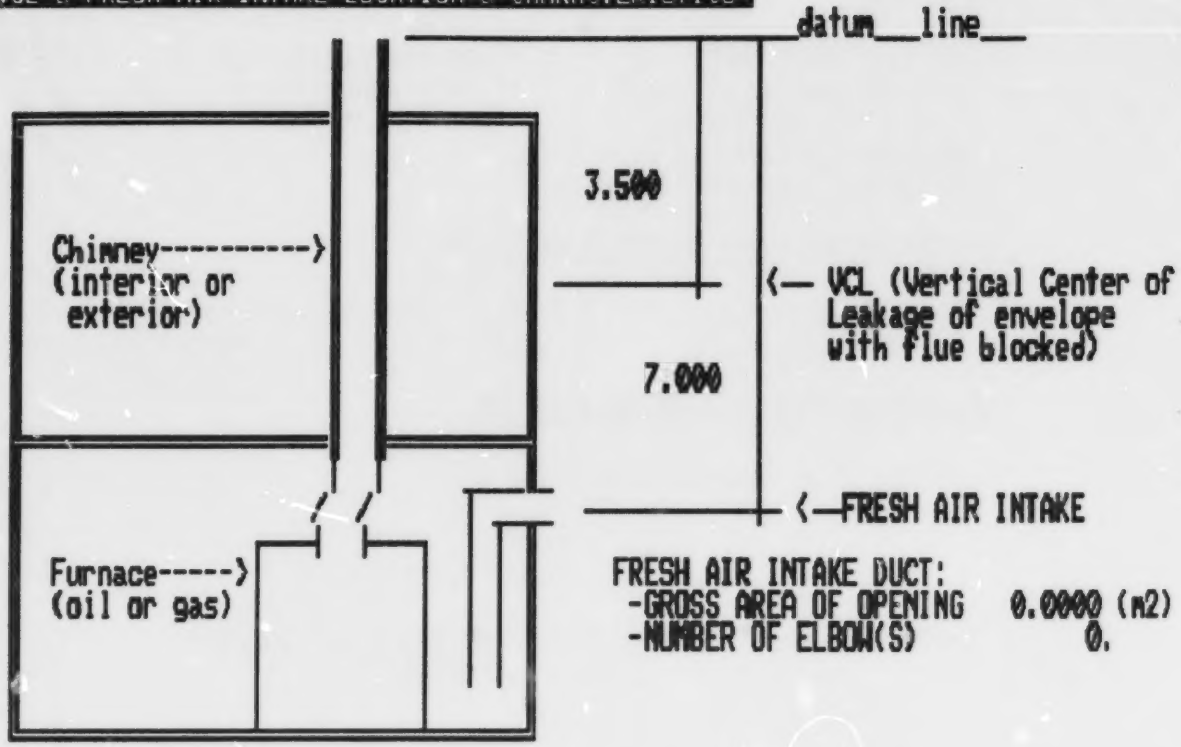
AMBIENT TEMPERATURE AND WIND SPEED

Outdoor Temperature	8.2 (C)	Wind Speeds:	-horizontal	0.0	(m/s)
Indoor Temperature	17.8 (C)		-vertical (up is +)	0.0	(m/s)

INITIAL TEMPERATURES OF ELEMENTS

Initial Flue Temperatures:	-flue gas	22.5	(C)
	-nodal point #1	30.2	(C)
	-nodal point #2	30.2	(C)
	-nodal point #3	30.2	(C)
Initial furnace temperatures:	-heat exchanger surface	32.0	(C)
	-stack gas	32.0	(C)

VCL & FRESH AIR INTAKE LOCATION & CHARACTERISTICS



DISTRIBUTION OF ENVELOPE LEAKS RELATIVE TO THE WIND DIRECTION

ENTER THE SELECTION WHICH BEST DESCRIBES THE ORIENTATION OF ENVELOPE LEAKS

(1. MAINLY WINDWARD 2. MAINLY LEEWARD 3. PARALLEL 4. UNIFORM 5. SHELTERED)

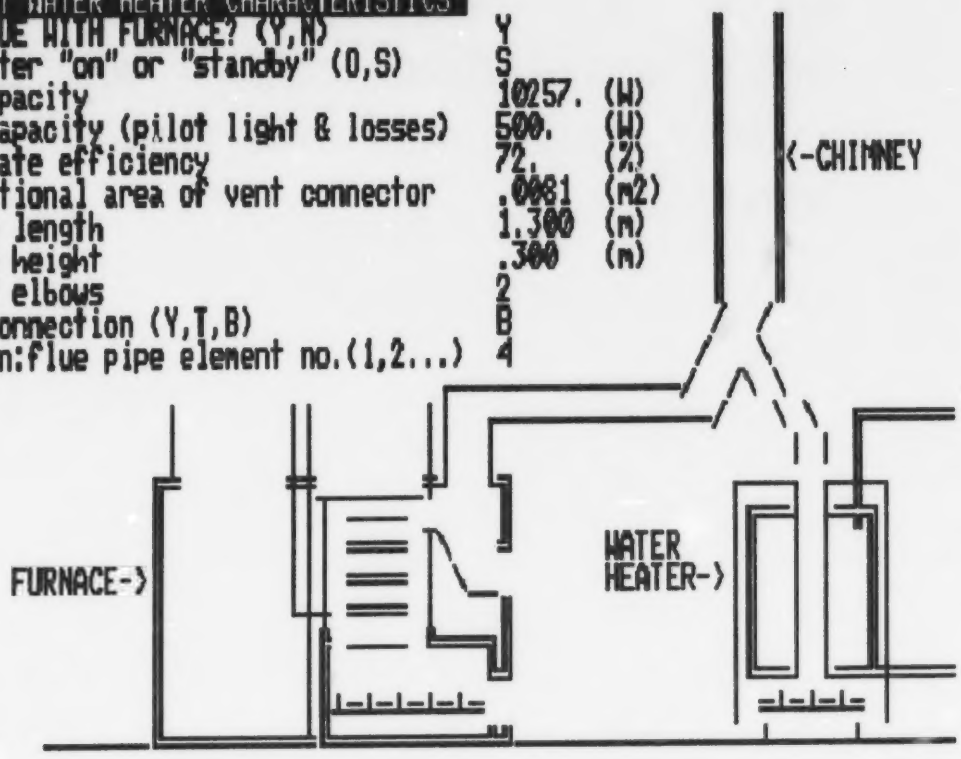
DEFAULT VALUE IS 5

INPUT YOUR SELECTION -> ?

HIT ENTER KEY TO USE DEFAULT

DOMESTIC HOT WATER HEATER CHARACTERISTICS

-SHARED FLUE WITH FURNACE? (Y,N)	Y
-water heater "on" or "standby" (O,S)	S
-burner capacity	10257. (W)
-standby capacity (pilot light & losses)	500. (W)
-steady state efficiency	72. (%)
-cross-sectional area of vent connector	.0081 (m2)
-flue pipe length	1.300 (m)
-flue pipe height	.300 (m)
-number of elbows	2
-type of connection (Y,T,B)	B
-connection:flue pipe element no.(1,2...)	4



FLUE DAMPER AND FLUE CAP

FLUE DAMPER:

-Is there a flue damper? (Y,N)	N	
-Damper activation: thermal or electric? (T,E)	E	
-Thermal activation temperature: -fully open	125.	(°C)
-fully closed	35.	(°C)
-Leakage area around flue damper when closed	.00240	(m2)

FLUE CAP:

-Horizontal wind pressure coefficient (horizontal wind pressure coefficient is needed even if 'Actual wind angle' below is not 0°)	.500	
-Actual wind angle (measured from horizontal: + up, - down)	0.0	(°)
-Wind pressure coefficient at that angle	.500	
-Wind speed at that angle	0.000	(m/s)
-Flue cap friction factor	6.00	

OPTIONAL SPECIFICATIONS

Furnace Thermostat Setting:

-thermostat setpoint	17.8 (°C)
-furnace thermostat band*	0.0 (°C)

House Thermal Characteristics:

-heated house volume	400.0 (m3)
-thermal conductivity of the house envelope	200.0 (W/°C)
-thermal mass of the house structure (L,M,or H)**	L

Mechanical Draft Inducer:

-Do you wish to include a draft inducer in the vent connector? (Y/N) N

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* -enter "0" if you want to specify the furnace ON & OFF times in TIME CONTROLS
  -enter the number of degrees for the thermostat band to simulate the dynamic performance of the envelope/furnace/thermostat system, e.g. "4.0"(C)

** enter "L" for ordinary wood frame structure, "M" for a wood frame house with interior mass e.g. brick, & "H" for a conc. block or solid masonry structure

TIME CONTROLS

Simulation Start Time	0.00	(sec)
Initial Time Step	1.00	(sec)
Furnace On	74.00	(sec)
Furnace Off	254.00	(sec)
Simulation Stop Time	600.00	(sec)

APPENDIX B

FIELD TEST DATA

DHW VENT CONNECTOR TEST RUN 1

25/2/87 sebshouse DURATION=600 s House Pressure: -5 Pa

Configuration: Direct to chimney, 0.2m above and perpendicular to furnace pipe/chimney connection.

Legend

t13: Temperature of flue gas @ 0.3m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
0.00	26.88	17.65	32.91	59.48	16.82	21.29	0.00	-86.00	9.09	17.98	8.45	23.90	Unsure of velocity measurement.
16.00	26.88	17.65	31.94	59.48	16.82	21.29	0.00	-20.00	8.86	18.31	8.45	23.80	
27.00	26.58	17.65	29.01	59.48	16.82	21.29	0.00	155.00	8.63	17.98	8.45	23.80	
38.00	26.88	17.65	31.61	59.48	16.82	21.29	0.00	-33.00	8.63	17.98	8.28	23.80	
49.00	26.88	17.65	33.40	59.48	16.82	21.29	0.00	-308.00	7.61	18.31	8.11	23.80	
61.00	26.82	17.65	33.24	59.48	16.82	21.29	0.00	255.00	4.55	18.31	8.11	23.80	
74.00	26.88	17.65	38.25	59.48	16.82	21.62	0.00	-6.00	4.98	20.79	8.11	23.10	
87.00	27.21	17.65	35.02	59.64	17.98	23.27	0.00	-143.00	4.07	22.12	8.11	20.20	
98.00	27.54	17.65	33.08	59.79	18.48	23.76	0.00	-156.00	6.10	22.28	8.28	18.10	
109.00	27.54	17.65	36.15	60.11	19.31	23.76	0.00	-156.00	7.88	26.23	8.61	17.30	
121.00	27.70	17.65	36.80	78.12	19.47	23.43	0.00	-28.00	9.09	27.86	8.45	17.50	Started DHW, 9 s backdraft @ DHW dilution
134.00	28.35	17.65	151.76	173.86	18.81	23.93	0.00	-3.00	9.09	22.45	8.28	21.20	inlet
147.00	27.86	17.65	166.90	214.76	17.98	22.94	0.00	0.00	9.32	20.30	8.45	25.00	
158.00	27.70	17.65	172.33	239.32	17.65	22.45	0.00	-3.00	9.54	19.80	8.28	27.40	
169.00	27.54	17.65	163.97	256.12	17.48	22.28	0.00	-11.00	8.13	19.47	8.28	29.50	
181.00	27.54	17.65	122.69	214.90	17.15	22.12	0.00	-256.00	7.61	19.47	8.11	30.60	Stopped DHW heater
195.00	27.54	17.65	98.99	184.82	17.65	22.28	0.00	-14.00	7.61	19.64	8.11	30.10	
208.00	27.54	17.65	89.90	167.32	17.48	22.61	0.00	37.00	7.04	19.80	8.11	29.70	
219.00	27.54	17.65	84.79	156.40	17.15	22.61	0.00	-31.00	7.33	20.30	8.11	29.20	
230.00	27.54	17.65	82.37	146.97	17.15	23.10	0.00	42.00	7.04	20.63	7.77	28.90	
242.00	27.72	17.67	78.29	138.33	17.17	23.12	0.00	0.00	7.61	20.81	7.79	28.50	
256.00	27.72	17.67	71.88	131.33	17.50	23.29	0.00	-102.00	7.33	20.65	7.79	28.30	
269.00	27.72	17.67	69.88	124.87	17.50	23.12	0.00	14.00	6.74	20.48	7.79	28.10	
280.00	27.72	17.67	66.49	119.95	17.17	23.12	0.00	-3.00	7.04	20.65	7.62	27.90	
291.00	27.72	17.67	67.88	115.45	17.67	23.29	0.00	-143.00	7.04	21.15	7.62	27.50	
303.00	27.74	17.69	64.96	111.10	17.52	23.31	0.00	-153.00	7.04	20.67	7.81	27.40	
317.00	27.74	17.69	60.77	106.70	17.19	23.47	0.00	-3.00	6.74	20.67	7.64	27.30	
330.00	27.74	17.69	59.36	102.87	17.19	23.31	-0.10	0.00	7.04	21.16	7.64	27.00	
341.00	27.74	17.69	59.52	99.77	17.19	23.80	0.10	65.00	6.74	21.50	7.47	26.90	
352.00	27.74	17.69	53.56	96.80	17.19	23.47	0.00	74.00	6.74	21.66	7.64	26.70	
370.00	27.74	17.69	59.36	92.48	17.19	23.80	0.00	-33.00	6.43	21.99	7.47	26.40	
384.00	27.74	17.69	54.19	89.94	17.85	24.13	0.00	-3.00	6.43	22.49	7.47	26.20	Partial backdrafting of DHW
397.00	27.74	17.69	54.35	87.38	17.69	24.13	0.00	-14.00	6.74	22.98	7.64	25.70	
408.00	27.90	17.69	59.36	85.58	17.85	24.30	0.10	-3.00	6.74	23.97	7.64	25.60	
419.00	27.90	17.69	57.80	83.92	17.85	24.46	0.10	0.00	6.43	23.14	7.47	25.60	
431.00	27.92	17.71	55.00	81.97	17.71	24.32	-0.10	-191.00	6.43	22.67	7.49	25.60	
444.00	27.92	17.74	32.16	80.31	17.71	24.32	0.00	-675.00	6.43	23.49	7.49	25.50	
457.00	27.92	17.74	56.25	78.94	17.71	24.48	-0.10	0.00	6.43	23.99	7.49	25.30	
468.00	27.92	17.74	56.25	77.57	17.87	24.81	0.00	-241.00	6.43	25.14	7.33	25.20	
479.00	27.92	17.74	56.88	76.50	18.04	24.97	0.00	0.00	6.43	5.63	7.33	24.90	
491.00	27.92	17.74	54.21	75.13	17.87	24.97	0.00	-86.00	6.74	23.33	7.33	25.10	
505.00	27.92	17.71	53.42	74.06	18.04	24.48	-0.10	-25.00	6.74	22.51	7.33	25.20	
518.00	27.92	17.71	52.01	72.99	17.87	24.32	-0.10	0.00	6.74	22.34	7.33	25.20	
529.00	27.92	17.71	50.90	72.22	17.87	24.15	0.00	-343.00	6.74	21.35	7.33	25.30	
540.00	27.76	17.71	49.00	71.30	17.71	23.99	0.00	-940.00	6.74	21.18	7.33	25.30	
552.00	27.79	17.74	50.14	70.56	17.74	24.02	0.10	-189.00	7.04	22.21	7.36	25.20	
565.00	27.79	17.74	49.19	69.79	17.74	24.35	0.00	0.00	6.74	21.38	7.02	25.30	
578.00	27.79	17.74	47.29	69.02	17.74	24.02	0.00	0.00	7.04	20.88	7.02	25.30	
589.00	27.79	17.74	49.03	68.41	17.74	24.02	0.00	108.00	0.00	21.21	7.02	25.30	

DHW VENT CONNECTOR TEST RUN 2
26/02/87 sebshouse DURATION=480 s House Pressure: -7 Pa

Configuration: Direct connection to chimney, 0.2m above and perpendicular to the furnace vent connector.

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
0.00	24.22	27.66	17.61	27.99	31.09	23.89	24.71	0.00	-25.00	ERR	27.82	8.40	13.60	DHW and furnace backdrafting.
16.00	24.22	27.66	17.61	26.19	28.48	21.42	23.72	-0.10	0.00	ERR	23.23	8.74	11.90	
27.00	23.72	27.17	17.61	24.05	27.50	20.59	22.41	0.00	-613.00	2.88	21.58	9.25	10.70	
38.00	23.72	27.01	17.61	25.53	28.64	20.59	22.41	0.20	0.00	4.55	24.38	8.57	11.10	
49.00	23.72	27.17	17.61	25.86	29.29	20.26	23.23	0.00	-135.00	2.03	29.29	8.40	11.30	
61.00	23.68	27.46	17.57	31.05	82.60	21.38	24.18	-0.20	304.00	4.07	25.16	8.36	10.30	Start DHW. DHW venting unstable,
76.00	55.18	27.46	17.57	106.15	137.67	23.03	27.95	-0.10	11.00	2.03	25.66	8.20	9.70	furnace backdrafting
87.00	60.19	27.13	17.57	98.77	155.49	22.37	25.82	0.00	0.00	ERR	23.19	8.36	9.20	At 120s, slight short circuit
98.00	46.65	26.97	17.57	64.38	166.42	21.38	23.35	-0.10	-6.00	2.03	21.21	8.53	8.70	for several seconds
110.00	50.77	26.80	17.57	71.17	176.99	20.71	23.03	-0.10	34.00	5.75	20.71	8.53	8.60	
121.00	73.78	27.95	17.57	163.06	183.93	21.05	31.21	-0.10	-995.00	2.03	25.98	8.36	8.20	
136.00	87.43	27.62	17.57	174.35	188.08	20.71	32.51	0.10	-64.00	4.07	25.49	8.36	8.10	
147.00	103.95	27.95	17.57	194.43	191.39	22.20	33.00	0.10	-280.00	0.00	26.64	8.53	8.00	
158.00	93.72	27.46	17.57	139.38	189.46	21.05	27.78	0.00	0.00	ERR	22.53	8.70	7.80	
170.00	79.57	26.97	17.57	87.58	189.46	20.38	24.18	0.00	-248.00	2.03	21.05	9.54	7.50	
181.00	73.78	26.80	17.57	71.63	190.98	20.05	22.04	0.00	20.00	ERR	20.22	9.21	7.40	
196.00	65.78	26.64	17.57	55.18	189.87	19.39	20.71	0.00	187.00	ERR	19.72	9.21	7.30	
207.00	60.65	26.64	17.57	47.92	192.22	19.56	20.05	0.00	17.00	4.98	19.56	9.21	7.30	
218.00	78.05	27.13	17.57	154.23	194.43	20.05	29.74	0.20	-135.00	4.98	24.34	8.70	7.50	
230.00	93.42	27.95	17.57	206.29	196.09	24.01	39.94	0.00	-105.00	6.43	28.44	8.03	7.80	
241.00	98.01	32.82	17.55	220.74	196.90	23.17	36.38	0.10	-759.00	8.86	26.46	8.18	13.50	Venting stable.
256.00	101.42	32.82	17.55	205.17	197.73	20.36	29.40	0.00	-6.00	8.38	22.51	8.51	22.30	
267.00	105.99	31.19	17.55	195.24	191.10	18.87	26.46	0.10	-25.00	7.61	21.36	8.18	24.70	At 270s, DHW shut off.
278.00	105.55	30.54	17.55	146.88	133.80	18.54	25.14	-0.10	25.00	6.43	22.84	8.34	23.50	
290.00	104.66	30.21	17.55	129.51	106.58	17.88	25.14	-0.10	0.00	6.43	23.66	8.51	23.60	
301.00	102.16	29.72	17.55	112.73	88.16	17.88	25.14	0.10	-64.00	6.43	22.84	9.02	24.40	Furnace venting unstable.
316.00	96.82	29.40	17.55	95.34	77.57	17.55	24.32	0.20	76.00	6.43	22.02	8.68	25.00	
327.00	92.06	29.40	17.55	89.36	70.85	17.55	24.32	0.00	-72.00	4.55	24.98	8.51	24.50	
338.00	88.91	29.72	17.55	89.66	65.45	22.02	26.78	-0.10	-3.00	4.55	24.98	9.02	21.60	DHW venting unstable. Furnace
350.00	85.75	29.72	17.55	85.75	60.95	23.17	29.56	0.00	-58.00	3.52	27.93	8.18	18.60	backdrafting
368.00	80.16	30.54	17.55	74.98	54.53	22.18	28.42	0.00	-6.00	6.43	25.47	8.01	18.90	
383.00	74.98	30.05	17.55	65.60	51.38	20.03	25.96	-0.10	0.00	4.98	23.66	8.18	20.50	Furnace venting unstable.
394.00	70.69	29.56	17.55	62.81	48.85	19.37	25.64	-0.10	11.00	4.07	25.64	8.34	20.20	
405.00	67.46	29.40	17.55	62.19	46.47	19.54	25.14	0.00	-664.00	4.07	28.91	8.18	19.20	
417.00	64.67	29.40	17.55	61.10	44.40	19.54	25.47	0.00	-50.00	6.10	29.40	8.01	18.70	
428.00	61.26	29.24	17.55	52.17	42.16	18.54	24.81	0.00	50.00	8.13	22.35	8.01	20.90	
443.00	56.10	28.75	17.55	45.36	40.40	17.71	23.83	-0.10	0.00	11.14	20.53	8.18	22.20	
454.00	51.54	28.58	17.55	41.20	38.95	17.55	23.17	0.00	-124.00	7.66	20.36	8.18	22.50	
465.00	47.58	28.42	17.55	38.15	37.50	17.38	23.01	0.20	-6.00	8.38	19.70	8.01	23.10	
477.00	44.08	28.26	17.55	36.05	36.38	17.05	22.84	-0.20	0.00	6.10	20.03	7.67	23.10	
														At 540s, DHW and furnace backdrafting.

DHW VENT CONNECTOR TEST RUN 3
26/02/87 sebshouse DURATION=600 s House Pressure: 0 Pa

Configuration: Direct to chimney. 0.2m above and perpendicular
to furnace pipe/chimney connection.

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
1.00	27.70	31.46	17.82	29.50	64.31	16.82	22.45	0.00	34.00	8.86	18.48	7.94	25.70	
17.00	27.87	31.62	17.82	29.99	64.62	16.82	22.61	-0.10	-25.00	9.32	18.48	8.28	25.70	
28.00	28.03	31.62	17.82	30.32	64.62	16.82	22.61	0.00	0.00	9.32	18.48	8.28	25.70	
39.00	28.03	31.62	17.82	30.32	64.62	16.99	22.61	0.00	11.00	9.54	18.65	7.94	25.80	
50.00	28.03	31.62	17.82	29.99	64.62	16.99	22.45	-0.10	0.00	9.32	18.65	8.28	25.70	
61.00	27.70	31.46	17.82	56.98	117.62	16.99	22.28	-0.10	0.00	11.50	18.48	7.94	27.20	Start DHW heater, no backdrafting
77.00	31.62	31.46	17.82	88.55	166.35	16.99	22.12	0.10	-441.00	11.68	18.48	7.61	29.20	
88.00	36.32	31.29	17.82	106.52	186.35	16.99	22.12	-0.10	-207.00	11.32	18.48	7.61	31.10	
99.00	42.26	31.29	17.82	118.49	198.09	16.99	22.12	0.10	-140.00	11.86	18.15	7.78	32.40	
110.00	48.32	31.29	17.82	126.72	205.53	16.82	21.79	0.10	0.00	11.68	18.48	7.61	33.50	
122.00	55.42	31.29	17.82	133.46	212.42	16.82	21.79	0.10	6.00	11.50	18.15	7.78	34.70	
137.00	62.60	31.29	17.82	140.31	216.14	16.82	21.79	0.10	0.00	11.86	18.15	7.78	35.70	
148.00	67.40	31.29	17.82	139.17	219.86	16.82	21.62	0.00	-191.00	12.86	17.98	7.61	36.40	
159.00	70.63	30.97	17.82	139.03	221.38	16.82	21.46	0.00	-3.00	12.70	17.82	7.78	36.90	
171.00	74.47	30.97	17.82	143.15	223.86	16.82	21.46	-0.20	-20.00	11.50	17.98	7.78	37.30	
182.00	79.19	30.97	17.82	148.66	225.51	16.82	21.62	0.10	0.00	11.50	17.98	7.78	37.70	
197.00	83.58	30.97	17.82	152.61	227.86	16.82	21.62	-0.10	0.00	11.86	17.98	7.78	38.30	
208.00	86.90	30.97	17.82	155.42	228.00	16.82	21.62	0.00	11.00	11.86	17.98	8.28	38.50	
219.00	89.90	30.97	17.82	157.11	228.69	16.82	21.46	-0.10	0.00	11.86	17.98	8.45	38.90	
231.00	92.30	30.97	17.82	157.95	230.07	16.82	21.62	0.00	14.00	11.86	18.15	8.62	39.00	
242.00	94.24	30.97	17.82	159.07	230.07	16.82	21.46	-0.10	-17.00	11.50	17.98	8.45	39.30	
257.00	96.62	30.97	17.82	160.61	231.03	16.82	21.46	0.10	355.00	11.32	17.98	8.28	39.50	Stopped DHW heater
268.00	97.36	30.97	17.82	130.60	170.39	16.82	21.62	0.10	6.00	10.57	18.15	8.45	38.20	
279.00	96.03	30.97	17.82	110.77	141.59	16.82	21.62	-0.10	-3.00	10.37	17.98	8.45	36.80	
291.00	93.94	30.97	17.82	97.36	126.58	16.82	21.62	-0.10	0.00	10.57	17.98	8.45	35.70	
302.00	89.44	30.95	17.80	85.68	115.42	16.80	21.60	0.10	-121.00	9.96	17.96	8.43	34.50	
317.00	84.47	30.95	17.80	79.02	108.12	16.80	21.77	0.10	0.00	9.96	17.96	8.26	33.60	
328.00	80.24	30.95	17.80	73.07	103.41	16.80	21.60	-0.10	0.00	10.95	17.96	7.92	32.90	
339.00	75.06	30.78	17.80	66.30	99.42	16.63	21.44	-0.10	-6.00	11.86	17.80	7.92	32.30	
351.00	69.39	30.62	17.80	61.18	95.86	16.63	21.27	-0.10	6.00	10.76	17.96	7.75	31.60	
368.00	64.15	30.64	17.82	59.02	90.95	16.65	21.62	0.10	3.00	10.17	18.15	7.94	30.70	
384.00	59.95	30.64	17.82	55.42	88.40	16.65	21.46	0.00	0.00	10.95	17.98	8.28	30.30	
395.00	56.51	30.48	17.82	53.06	86.30	16.65	21.46	-0.10	-91.00	9.54	18.15	7.94	29.90	
406.00	54.63	30.64	17.82	52.90	84.49	16.65	21.62	0.00	-3.00	9.96	17.98	8.28	29.50	
417.00	52.43	30.64	17.82	50.85	82.83	16.65	21.46	0.00	0.00	9.75	17.82	7.94	29.20	
429.00	49.90	30.64	17.82	48.95	81.16	16.65	21.46	0.00	-881.00	10.57	17.82	7.94	28.90	
444.00	47.20	30.48	17.82	47.20	79.80	16.65	21.46	0.00	-6.00	9.09	17.98	7.78	28.60	
455.00	45.77	30.48	17.82	46.73	78.58	16.65	21.62	0.10	-72.00	10.37	17.82	7.78	28.40	
466.00	43.86	30.48	17.82	44.82	77.52	16.65	21.46	0.10	-6.00	9.96	17.82	7.78	28.30	
477.00	42.26	30.48	17.82	44.02	76.60	16.65	21.46	0.10	99.00	9.75	17.98	7.78	28.00	
489.00	40.84	30.34	17.84	42.60	75.40	16.67	21.48	-0.10	17.00	9.54	18.00	8.30	27.80	
504.00	39.56	30.34	17.84	42.12	74.79	16.67	21.48	0.10	105.00	9.32	18.00	7.96	27.70	
515.00	38.75	30.34	17.84	42.12	74.03	16.67	21.48	0.00	-45.00	9.32	18.00	8.30	27.50	
526.00	37.95	30.50	17.84	41.64	73.41	16.67	21.64	-0.10	-3.00	9.09	18.00	8.30	27.40	
537.00	37.14	30.34	17.84	41.16	72.80	16.67	21.48	0.20	-201.00	9.54	17.84	8.47	27.30	
549.00	36.32	30.32	17.82	40.66	72.02	16.82	21.46	0.00	11.00	9.54	17.98	8.28	27.20	
564.00	35.67	30.32	17.82	39.70	71.56	16.82	21.46	0.10	-11.00	9.54	17.98	8.28	27.00	
575.00	35.02	30.32	17.82	39.54	71.10	16.82	21.46	-0.10	-6.00	9.09	17.98	8.45	26.90	
586.00	34.54	30.32	17.82	39.54	70.79	16.82	21.62	-0.10	3.00	8.86	18.15	8.62	26.80	
597.00	34.21	30.32	17.82	39.22	70.33	16.82	21.46	-0.10	0.00	9.32	17.98	8.79	26.80	

DHW VENT CONNECTOR TEST RUN 4
26/02/87 sebshouse DURATION=600 s House Pressure: -5 Pa

Configuration: Direct to chimney, 0.2m above and perpendicular to furnace pipe/chimney connection.

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
0.00	32.55	30.44	17.78	39.66	66.28	17.11	22.57	0.00	-183.00	6.10	19.44	8.58	25.00	
16.00	32.72	30.44	17.78	41.42	66.28	17.28	23.07	-0.20	-3.00	9.32	19.60	8.24	25.00	
27.00	32.39	30.28	17.78	38.69	65.97	17.11	22.41	-0.20	-164.00	7.88	18.77	8.41	25.20	
38.00	32.23	29.95	17.78	39.18	65.82	17.28	22.41	0.00	-36.00	6.10	19.60	8.41	25.10	
49.00	32.39	30.28	17.78	40.78	65.97	17.61	23.07	-0.10	0.00	8.38	19.93	8.24	24.90	
61.00	32.39	30.28	17.78	39.82	65.97	17.78	22.74	0.10	0.00	7.61	19.60	8.58	25.10	
74.00	32.23	30.28	17.78	39.82	65.97	23.56	32.23	-0.10	-14.00	8.13	105.46	8.58	25.20	Start furnace, backdrafts until
87.00	32.07	32.39	17.78	38.85	65.97	20.59	64.58	-0.10	45.00	8.13	131.57	8.41	28.00	82 s.
98.00	31.74	35.31	17.78	37.73	65.82	19.44	79.31	-0.10	-137.00	9.09	131.28	8.24	31.30	DHW heater draws well for entire
109.00	31.42	38.37	17.78	36.28	65.66	18.77	87.92	-0.10	3.00	9.32	127.70	7.90	34.00	test
121.00	30.77	40.30	17.78	35.31	65.66	18.61	95.10	-0.20	-45.00	9.09	139.42	8.24	36.10	
134.00	30.44	41.42	17.78	34.82	65.51	18.11	100.14	0.00	-31.00	10.17	137.57	7.57	38.40	
147.00	29.62	43.02	17.78	34.17	65.35	17.94	103.10	0.20	-6.00	9.75	137.00	7.90	40.10	
158.00	28.81	43.98	17.78	34.17	65.35	17.94	107.51	0.10	-47.00	9.54	146.09	7.73	41.20	
169.00	28.16	44.62	17.78	34.01	65.35	17.94	111.47	-0.10	-75.00	9.32	150.89	8.24	42.20	
181.00	28.01	45.59	17.80	34.19	65.37	17.96	114.55	0.00	-14.00	9.32	155.55	8.60	43.30	
194.00	27.68	46.39	17.80	34.19	65.37	18.63	118.33	0.00	-47.00	9.54	158.78	8.60	44.10	
207.00	27.19	47.66	17.80	33.87	65.37	18.46	118.62	0.20	-88.00	10.95	142.28	8.43	45.40	
218.00	26.87	48.30	17.80	33.22	65.06	18.63	119.63	-0.10	-6.00	10.17	147.38	8.60	45.70	
229.00	26.70	48.61	17.80	33.38	65.06	18.63	122.53	0.10	-118.00	9.96	156.53	8.60	46.20	
241.00	26.72	49.11	17.82	33.40	65.08	18.81	124.85	0.00	-566.00	10.17	155.14	8.28	46.90	
254.00	26.39	49.58	17.82	33.24	65.08	18.81	110.63	0.00	0.00	9.54	96.47	8.28	46.90	Furnace shut off
267.00	26.39	47.20	17.82	33.89	65.08	18.81	91.25	-0.10	0.00	8.38	78.74	7.94	44.70	
278.00	26.72	45.14	17.82	34.38	65.08	18.81	83.28	-0.20	-17.00	9.75	68.48	7.94	43.00	
289.00	26.72	43.86	17.82	34.05	65.08	18.81	75.84	0.00	-321.00	8.13	61.20	8.28	41.60	
300.00	26.91	42.44	17.84	35.04	65.10	18.67	71.88	-0.10	37.00	7.88	62.62	8.47	40.00	
314.00	27.07	41.64	17.84	35.69	65.41	18.17	67.42	0.10	-36.00	8.13	54.33	8.47	38.80	
327.00	27.07	40.84	17.84	35.69	65.41	18.17	62.93	0.10	3.00	8.38	48.49	8.47	37.80	
338.00	27.23	40.20	17.84	36.17	65.41	18.17	60.14	-0.20	-177.00	7.33	51.18	8.47	36.60	
349.00	27.40	39.72	17.84	36.17	65.41	18.00	56.85	0.20	-6.00	7.04	45.00	8.81	35.80	Furnace fan shuts off
367.00	27.95	38.97	17.90	36.39	65.47	18.23	53.45	-0.10	0.00	8.86	44.28	8.70	34.60	
381.00	28.11	38.65	17.90	36.39	65.47	18.23	51.71	-0.10	-31.00	7.04	43.46	8.70	33.90	
394.00	28.76	38.17	17.90	37.04	65.47	18.56	50.92	0.00	-50.00	7.04	44.26	8.53	33.40	
405.00	28.93	38.01	17.90	37.52	65.47	18.56	49.98	0.10	0.00	7.04	44.42	8.03	32.90	
416.00	29.25	37.68	17.90	37.52	65.62	18.56	49.03	0.20	34.00	7.61	42.50	8.87	32.50	
427.00	29.61	37.55	17.93	37.71	65.65	18.76	48.26	0.00	31.00	7.61	42.53	8.73	32.20	
442.00	29.77	37.23	17.93	37.71	65.49	18.76	46.67	0.30	-20.00	8.38	37.55	8.39	32.10	
455.00	29.61	37.07	17.93	36.10	65.18	18.59	43.81	0.20	11.00	9.54	31.73	7.89	32.10	
466.00	29.28	36.75	17.93	35.29	65.18	18.26	42.37	0.10	128.00	7.88	31.56	7.89	31.80	
477.00	29.28	36.42	17.93	35.29	65.18	18.26	42.05	0.00	0.00	8.13	32.86	8.39	31.40	
488.00	29.63	36.28	17.95	36.44	65.20	18.11	42.39	0.10	-11.00	6.10	38.22	8.75	31.00	
502.00	29.79	36.28	17.95	36.76	65.51	18.11	41.75	0.10	14.00	8.38	32.39	8.58	31.00	
515.00	29.79	36.12	17.95	36.12	65.20	18.11	40.30	0.20	0.00	7.61	32.56	8.92	30.70	
526.00	29.79	35.96	17.95	36.12	65.20	18.11	39.82	0.20	-774.00	7.61	31.75	8.58	30.60	
537.00	29.95	35.80	17.95	36.12	65.20	17.95	39.34	0.20	-3.00	8.13	30.61	8.58	30.50	
548.00	29.97	35.82	17.97	36.78	65.22	17.97	39.52	-0.10	34.00	7.04	33.39	8.60	30.10	
562.00	29.97	35.49	17.97	37.27	65.22	18.13	39.36	0.10	14.00	7.04	34.20	8.43	29.90	
575.00	30.14	35.49	17.97	37.75	65.53	18.13	39.36	0.10	-11.00	6.74	35.82	8.43	29.60	
586.00	30.46	35.49	17.97	38.07	65.22	18.13	39.04	0.00	76.00	7.33	35.17	8.60	29.50	
597.00	30.63	35.33	17.97	38.07	65.53	18.13	38.56	-0.10	-17.00	5.75	36.14	8.60	29.20	

DHW VENT CONNECTOR TEST RUN 5
26/02/87 sebshouse DURATION=480 s House Pressure: 0 Pa

Configuration: Y-merge into furnace vent connector, 2.95m from furnace dilution

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
1.00	48.16	29.66	16.99	60.11	78.58	16.49	31.46	0.10	-72.00	8.13	17.82	7.94	27.30	
17.00	44.34	29.17	16.99	54.94	75.84	16.32	29.01	-0.10	11.00	8.13	17.82	7.94	26.80	
28.00	42.42	29.01	16.99	53.37	73.55	16.99	28.03	0.00	-3.00	7.61	18.31	8.11	26.60	
39.00	42.26	29.01	16.99	52.58	71.25	16.99	29.01	0.00	-3.00	7.04	18.15	8.11	26.20	
50.00	41.46	29.01	16.99	50.85	69.56	16.99	28.68	0.00	-137.00	7.04	18.15	8.11	25.90	
62.00	38.75	28.87	17.01	80.88	110.64	16.84	38.59	0.20	-61.00	8.86	18.00	8.13	25.90	Start DHW heater @ 60s, 2s
77.00	36.66	30.17	17.01	131.34	162.03	16.51	50.55	0.00	20.00	8.86	17.84	7.96	27.50	backdraft @ DHW dilution
88.00	37.95	31.31	17.01	148.54	181.52	16.34	54.81	-0.10	-3.00	9.54	17.67	7.80	29.00	
99.00	38.43	31.80	16.97	151.22	192.45	16.34	54.02	-0.20	-86.00	8.86	17.67	7.80	30.10	
111.00	41.64	32.29	16.97	162.87	198.80	16.17	58.88	-0.10	11.00	9.54	17.67	7.80	31.10	
122.00	45.95	32.61	17.01	171.38	204.45	16.17	62.31	0.20	-31.00	9.09	17.34	7.80	32.10	
137.00	48.33	33.26	17.01	175.41	208.72	16.17	65.25	0.10	-91.00	9.32	17.67	7.96	32.80	
148.00	52.92	33.59	17.01	176.94	210.23	16.17	64.79	0.00	-225.00	9.32	17.34	7.96	33.40	
159.00	55.75	33.75	16.97	176.66	211.61	16.17	61.53	-0.20	-3.00	9.54	17.34	8.13	33.90	
171.00	56.69	33.75	16.97	181.24	212.85	16.17	63.08	0.10	28.00	9.32	17.34	8.47	34.30	
182.00	59.21	34.25	17.06	182.09	214.25	16.19	64.03	0.00	0.00	9.54	17.36	8.49	34.70	
197.00	60.46	34.41	17.03	184.86	215.90	16.19	67.44	0.00	-228.00	9.32	17.36	8.49	34.90	
208.00	62.64	34.90	17.03	188.46	216.86	16.19	70.06	0.00	0.00	9.54	17.36	8.49	35.20	
219.00	64.03	35.06	17.06	190.25	217.28	16.36	71.75	-0.10	11.00	9.54	17.36	7.98	35.60	
231.00	67.75	35.22	17.06	192.60	218.65	16.19	73.59	0.10	-31.00	9.75	17.36	8.15	35.80	
242.00	67.59	35.22	17.03	149.54	173.35	16.36	56.39	0.10	0.00	9.09	17.36	8.49	35.30	Stopped DHW
257.00	67.75	33.77	17.03	115.33	135.64	16.36	48.20	-0.10	-110.00	9.09	17.69	8.15	34.10	
268.00	69.44	33.12	17.03	101.69	118.09	16.19	45.02	-0.10	6.00	8.63	17.36	8.15	32.90	
279.00	67.59	32.47	17.03	92.93	107.44	16.19	42.14	-0.10	6.00	8.13	17.36	8.15	32.10	
291.00	66.82	32.31	17.03	85.43	99.92	16.53	38.45	0.10	-426.00	8.13	18.02	8.49	31.30	
302.00	64.65	31.82	17.03	79.08	93.53	16.53	36.35	-0.10	-153.00	8.13	17.86	8.49	30.50	
317.00	63.10	31.49	17.03	73.59	88.44	16.53	36.19	0.00	-209.00	7.88	17.69	8.49	29.90	
328.00	59.68	31.33	17.03	68.21	84.68	16.36	34.09	0.10	0.00	7.88	17.69	8.49	29.40	
339.00	56.71	31.01	17.03	64.34	81.65	16.36	33.28	0.20	6.00	8.63	17.86	8.15	28.80	
351.00	52.94	30.84	17.03	59.68	79.08	16.36	30.84	0.00	-118.00	8.13	17.69	8.15	28.30	
369.00	47.90	30.54	17.05	54.84	74.98	16.38	29.07	-0.10	-64.00	8.38	17.38	7.67	27.40	
384.00	44.88	30.21	17.05	52.01	72.84	16.55	28.09	-0.10	0.00	9.09	18.04	7.84	27.00	
395.00	42.32	30.05	17.05	48.85	71.15	16.55	26.95	0.00	-516.00	9.32	18.04	8.00	26.80	
406.00	39.11	29.89	17.05	45.67	69.46	16.38	25.63	0.10	225.00	9.54	17.71	7.84	26.60	
418.00	36.70	29.72	17.05	43.44	67.92	16.55	24.98	-0.20	0.00	8.38	17.98	7.67	26.20	
429.00	35.61	29.60	17.09	43.16	66.57	16.92	25.67	-0.10	-191.00	7.33	17.92	7.88	25.70	
444.00	36.09	29.60	17.09	43.00	65.17	16.59	25.67	0.00	-183.00	7.33	17.75	7.88	25.50	
455.00	35.28	29.60	17.09	42.68	64.25	16.42	26.33	0.10	-11.00	7.04	17.75	8.05	25.20	
466.00	35.12	29.60	17.09	42.36	63.47	16.42	26.33	0.00	-50.00	6.74	17.75	8.05	25.10	
477.00	34.15	29.60	17.09	41.88	62.54	16.25	26.66	-0.10	-300.00	7.88	17.92	8.05	25.00	

DHW VENT CONNECTOR TEST RUN 6
26/02/87 sebshouse DURATION=480 s House Pressure: -5 Pa

Configuration: Y-merge into furnace vent connector, 2.95m from furnace dilution

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (EXH indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
1.00	24.52	28.29	17.05	35.44	52.36	17.92	26.49	0.10	20.00	3.52	29.60	8.55	18.90	Furnace and DHW experiencing
17.00	25.02	28.29	17.09	35.93	52.36	19.24	26.49	-0.10	3.00	4.07	32.37	8.89	17.80	unstable venting
28.00	25.35	28.46	17.09	35.93	52.36	19.91	26.49	-0.10	0.00	4.55	29.93	9.06	17.40	
39.00	25.51	28.46	17.09	35.93	52.36	19.24	26.66	0.00	25.00	4.07	27.31	8.89	17.90	
50.00	25.51	28.46	17.09	35.44	52.21	18.75	26.66	0.00	-151.00	4.98	25.02	9.06	18.70	
62.00	25.67	28.46	17.09	94.63	110.57	18.41	44.12	0.00	-45.00	6.74	25.18	8.89	19.60	Start DHW @ 60s, stable venting
77.00	27.97	30.25	17.09	146.21	158.46	18.08	66.88	-0.10	-3.00	7.04	22.55	8.89	21.30	starts
88.00	31.39	31.72	17.09	165.73	178.95	17.92	77.61	0.00	76.00	9.54	20.57	8.89	24.20	
99.00	33.66	32.37	17.09	159.86	191.41	17.42	67.49	0.00	-143.00	7.88	19.24	8.89	26.40	
111.00	38.67	32.69	17.09	180.62	199.69	17.75	84.43	0.10	-3.00	7.61	20.73	9.06	27.30	
122.00	45.07	33.83	17.09	195.83	206.31	17.42	96.26	0.00	14.00	7.88	19.91	8.89	28.80	
137.00	52.21	34.96	17.09	196.10	210.58	17.09	93.43	0.10	-11.00	7.88	19.57	8.89	30.10	
148.00	57.86	35.12	17.09	204.79	212.78	17.09	99.68	0.00	-3.00	7.88	19.57	9.06	30.70	
159.00	64.09	35.61	17.09	207.27	216.22	17.09	95.22	0.00	-230.00	8.13	19.24	9.39	31.60	
171.00	69.04	35.93	17.09	208.65	217.74	17.09	91.94	0.10	0.00	9.09	19.08	8.72	32.50	
182.00	71.06	36.12	17.12	211.15	220.11	17.28	94.21	0.00	-533.00	9.96	18.94	8.08	33.40	
197.00	70.14	36.12	17.12	198.47	221.21	17.12	81.43	0.10	172.00	8.63	18.44	8.08	33.90	
208.00	75.35	36.12	17.12	209.09	221.62	17.12	92.56	0.00	-47.00	9.09	18.78	8.08	34.10	
219.00	79.77	36.44	17.12	215.15	223.14	17.12	100.89	0.00	-259.00	8.38	18.94	8.08	34.30	
231.00	85.21	37.09	17.12	219.28	224.24	17.28	104.14	-0.10	0.00	8.13	19.11	[illegible]	34.50	
242.00	89.27	37.09	17.12	166.60	168.41	17.28	86.72	0.00	-285.00	7.04	19.11	8.08	[illegible].00	Stopped DHW, stable venting
257.00	93.76	35.63	17.12	138.57	132.58	17.78	81.43	0.00	-3.00	6.74	20.10	7.91	32.80	continues
268.00	94.50	35.15	17.12	122.66	116.28	17.45	72.14	-0.10	-14.00	6.74	19.77	8.08	32.10	
279.00	93.61	34.50	17.12	112.20	106.05	17.28	69.52	0.10	-108.00	6.10	20.60	8.58	31.20	
291.00	93.01	34.18	17.12	105.17	98.81	17.28	66.59	0.00	-61.00	6.10	20.60	8.75	30.30	
302.00	90.64	33.71	17.14	97.05	92.73	17.14	59.94	0.00	0.00	7.33	20.12	9.11	29.90	DHW venting becomes unstable
317.00	84.33	33.39	17.14	85.38	87.94	16.97	50.36	0.00	-3.00	6.43	19.62	8.77	29.60	furnace venting stable
328.00	79.78	32.74	17.14	80.54	84.33	16.97	48.30	0.10	-67.00	6.74	19.29	8.77	29.10	
339.00	75.06	32.58	17.14	75.22	81.30	16.97	43.69	-0.10	-386.00	6.74	19.13	8.77	28.80	
351.00	71.39	32.09	17.14	72.46	78.72	17.14	43.69	0.00	-269.00	5.75	19.96	8.26	28.30	
368.00	68.48	31.95	17.16	67.87	74.78	17.16	41.79	0.00	0.00	6.43	19.81	8.62	27.50	
384.00	65.09	31.62	17.16	65.70	72.79	17.16	43.70	-0.10	-14.00	5.38	21.46	8.62	26.90	
395.00	64.31	31.62	17.16	64.93	71.10	17.16	41.95	0.10	-3.00	5.38	21.63	8.96	26.30	
406.00	61.83	31.62	17.16	61.36	69.56	17.16	40.66	-0.10	-33.00	8.13	20.80	9.13	26.20	
418.00	54.01	31.46	17.16	54.48	68.02	17.16	34.22	0.00	0.00	6.10	19.64	8.79	26.30	
429.00	54.16	30.97	17.16	56.67	66.79	17.82	38.58	0.10	-56.00	5.38	23.44	8.28	25.10	
444.00	54.01	31.13	17.16	55.42	65.70	17.99	36.32	0.10	-20.00	6.74	21.13	8.28	25.10	
455.00	50.54	30.97	17.16	51.17	64.47	17.49	32.92	0.10	0.00	7.04	19.64	8.28	25.30	
466.00	48.00	30.81	17.16	49.59	63.69	17.32	33.25	0.00	128.00	4.98	20.14	8.28	25.10	
478.00	47.68	30.81	17.16	49.43	63.07	17.49	33.25	0.00	-3.00	4.07	21.13	8.12	24.70	

DHW VENT CONNECTOR TEST RUN 7
25/02/87 sebshouse DURATION=480 s House Pressure: -7 Pa

Configuration: Y-merge into furnace vent connector, 2.95m from furnace dilution.

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
1.00	26.77	28.89	17.20	28.24	54.20	18.52	23.65	0.10	14.00	0.00	21.50	8.66	11.40	Furnace and DHW backdrafting.
17.00	26.44	28.56	17.20	28.07	53.89	19.02	23.48	0.10	-42.00	4.07	21.17	9.00	10.70	
28.00	26.44	28.89	17.20	31.50	53.57	21.50	24.47	0.00	-11.00	ERR	23.65	9.17	10.40	
39.00	26.44	28.89	17.20	29.38	53.57	20.18	24.80	-0.10	-28.00	2.03	22.82	9.00	9.80	
50.00	26.27	28.89	17.20	28.07	53.26	19.68	24.30	0.20	-341.00	2.88	22.00	9.17	9.60	
62.00	25.74	28.53	17.16	30.97	90.66	18.98	23.61	0.00	-230.00	ERR	21.46	8.79	9.20	Start DHW @ 60s
75.00	34.70	28.53	17.16	100.92	150.64	18.98	22.95	0.10	-11.00	4.55	27.38	8.96	9.10	
88.00	40.66	28.53	17.16	162.72	174.98	20.80	47.84	0.10	-78.00	5.38	29.99	8.96	9.70	at 90s, DHW venting but unstable,
99.00	39.54	30.97	17.16	179.29	187.04	19.81	66.94	-0.20	125.00	8.86	24.43	8.12	15.80	furnace venting stable
110.00	39.06	32.43	17.16	163.00	195.61	18.15	60.58	0.00	28.00	8.38	20.31	8.12	22.40	
122.00	41.82	32.96	17.20	175.99	202.54	17.86	76.19	0.20	-323.00	8.13	19.85	8.33	23.60	
135.00	47.09	33.77	17.20	191.22	208.05	17.36	87.24	-0.10	31.00	9.09	19.85	8.33	25.70	
148.00	52.31	34.58	17.20	191.91	210.67	17.20	86.79	0.20	6.00	8.86	19.68	8.33	28.00	
159.00	56.71	34.74	17.20	194.26	213.28	17.20	89.34	0.10	355.00	7.88	19.19	8.16	29.40	
170.00	64.19	35.55	17.20	208.60	216.73	17.03	99.63	-0.70	-3.00	8.13	19.35	7.82	30.30	
182.00	70.08	36.22	17.22	214.40	218.12	17.05	108.19	-0.10	37.00	7.61	19.87	8.35	31.10	
195.00	76.21	37.02	17.22	224.46	219.09	16.72	111.12	-0.10	-594.00	9.96	19.70	8.68	32.20	
208.00	74.68	37.02	17.22	205.59	220.60	16.72	92.21	0.10	-110.00	8.38	19.21	8.01	33.20	
219.00	76.55	37.02	17.22	216.61	222.95	16.72	102.60	0.00	-1054.00	9.09	19.21	8.18	33.50	
230.00	81.83	37.35	17.22	216.75	222.12	17.05	107.90	0.00	56.00	7.88	19.70	8.85	33.90	
242.00	88.01	37.83	17.22	226.39	223.22	17.05	119.13	0.00	-64.00	7.61	19.87	8.18	33.80	at 240s, stopped DHW, DHW
255.00	95.04	38.31	17.22	233.29	216.75	16.72	123.47	-0.10	-121.00	6.74	20.20	8.01	33.60	backdrafting; furnace venting
268.00	100.09	37.83	17.22	161.23	152.67	16.72	88.91	-0.20	-1692.00	8.86	19.70	7.33	33.50	stable
279.00	94.74	36.22	17.22	132.23	127.07	16.72	76.05	-0.20	-17.00	4.98	21.19	7.67	32.40	Furnace venting becomes unstable
290.00	99.79	35.41	17.22	128.36	112.44	17.55	71.46	0.10	-94.00	5.38	26.13	7.84	30.00	
302.00	101.86	35.09	17.22	118.40	102.01	17.88	71.31	0.00	91.00	7.04	25.64	7.84	28.40	
315.00	100.53	34.76	17.22	106.87	94.45	17.55	68.54	0.00	0.00	5.38	23.34	8.01	28.30	
328.00	99.20	34.44	17.38	102.90	88.76	18.38	66.22	0.00	-256.00	6.10	26.46	7.84	26.80	
339.00	96.08	34.28	17.22	92.36	84.70	17.88	56.73	0.00	-17.00	7.04	22.18	8.18	27.40	
350.00	89.06	33.63	17.22	82.74	81.07	17.22	50.28	0.00	0.00	4.98	21.03	8.35	27.40	
368.00	85.32	33.00	17.24	83.51	76.07	20.72	51.24	-0.10	59.00	2.88	24.84	8.37	23.30	Furnace backdrafting
381.00	84.42	32.67	17.24	82.00	73.17	21.71	44.90	-0.10	0.00	0.00	29.26	8.20	19.40	
394.00	82.15	32.02	17.24	79.88	71.02	20.88	36.88	-0.10	34.00	4.98	27.62	8.20	16.40	
405.00	80.18	31.86	17.24	75.16	69.17	21.21	42.82	0.00	0.00	2.88	29.26	8.20	15.00	
416.00	78.20	32.02	17.24	72.86	67.17	24.34	42.50	0.10	17.00	2.88	27.30	8.20	13.70	
428.00	76.22	31.86	17.24	69.33	65.31	23.69	45.85	0.10	-67.00	4.98	27.46	8.20	14.10	DHW and furnace venting stable
441.00	73.47	32.02	17.24	64.54	63.76	21.71	45.38	0.10	-56.00	4.98	25.49	8.03	15.90	
454.00	69.64	32.02	17.24	61.59	62.06	20.39	43.30	0.00	0.00	6.43	23.69	8.03	18.00	
465.00	64.39	31.86	17.24	56.91	60.97	19.23	40.10	0.00	45.00	5.75	22.04	8.37	19.80	
476.00	60.34	31.70	17.24	54.08	59.88	18.56	38.17	0.10	0.00	4.07	21.87	8.03	20.80	
										0.00				

DHW VENT CONNECTOR TEST RUN 8
26/02/87 sebshouse DURATION=480 s House Pressure: -5 Pa

Configuration: Y-merge into furnace vent connector, 2.95m from furnace dilution.

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
0.00	22.72	28.95	17.26	28.46	33.83	18.09	24.69	0.20	-6.00	4.07	26.66	8.22	19.10	DHW and furnace venting unstable
16.00	22.88	29.11	17.26	27.48	33.67	17.92	24.53	0.10	0.00	5.75	22.88	8.22	19.70	
27.00	22.72	28.95	17.26	27.32	33.67	17.59	24.03	0.10	0.00	4.07	23.71	8.39	19.70	
38.00	22.72	28.95	17.26	27.64	33.51	17.59	24.53	-0.10	-485.00	6.10	22.72	8.72	20.10	
49.00	22.22	28.95	17.26	25.84	33.34	19.25	23.54	-0.10	37.00	5.38	73.49	8.39	20.80	
61.00	22.06	29.77	17.26	26.17	33.34	21.07	56.92	-0.10	-148.00	7.61	134.13	8.22	22.20	at 55s, furnace on, stable
74.00	21.73	33.34	17.26	25.35	33.02	20.08	76.39	0.10	25.00	5.75	160.14	8.22	25.70	venting
87.00	21.56	36.58	17.26	25.18	33.02	19.25	89.40	0.00	-225.00	5.75	171.31	8.22	28.50	
98.00	21.56	38.83	17.26	24.86	32.86	19.08	97.60	0.00	-243.00	6.10	180.62	8.05	30.50	
109.00	21.56	40.28	17.26	25.35	32.86	19.25	104.26	0.10	108.00	9.32	175.62	8.05	32.20	
121.00	20.90	41.88	17.26	24.03	32.69	18.42	106.91	-0.10	-33.00	7.33	171.59	8.05	34.50	Furnace fan comes on
134.00	20.90	42.84	17.26	23.87	32.53	18.92	111.59	0.10	-25.00	7.04	182.28	8.22	36.00	
147.00	20.74	44.12	17.26	23.71	32.53	18.58	115.82	0.10	-88.00	7.88	180.62	8.05	37.40	
158.00	20.74	44.92	17.26	23.71	32.21	18.58	118.00	0.10	-91.00	7.88	181.45	8.22	38.80	
169.00	20.74	45.87	17.26	23.71	32.21	18.92	120.76	-0.10	17.00	8.13	185.05	8.05	39.70	
181.00	20.41	46.67	17.26	23.38	32.04	18.58	123.79	0.00	-121.00	7.61	189.34	8.22	40.60	
194.00	20.41	47.30	17.26	23.54	32.04	18.58	126.67	0.00	-761.00	8.38	186.02	8.39	41.60	
207.00	20.41	48.10	17.26	23.05	32.04	18.58	128.54	0.00	-248.00	7.88	189.06	9.06	42.40	
218.00	20.08	48.89	17.26	22.88	31.88	18.58	128.40	0.00	-272.00	8.38	181.59	8.72	43.50	
229.00	20.08	49.52	17.26	22.72	31.88	18.92	130.40	0.00	-310.00	8.13	188.92	8.39	44.10	
241.00	20.10	50.18	17.28	22.74	31.74	19.10	131.00	0.10	25.00	8.38	151.59	8.24	45.00	
254.00	20.10	48.91	17.28	22.74	31.74	19.27	104.57	-0.10	-526.00	7.33	107.66	8.41	43.30	at 250s, furnace off, stable
267.00	20.26	45.89	17.28	23.07	31.74	19.10	94.35	0.00	0.00	7.04	95.39	8.41	41.60	venting
278.00	20.26	44.30	17.28	23.07	31.58	18.94	87.46	-0.10	-25.00	6.10	88.97	8.07	40.10	
289.00	20.26	43.18	17.28	22.90	31.58	18.60	78.24	0.00	-20.00	8.13	69.21	7.90	39.10	
301.00	20.16	41.96	17.34	23.13	31.64	18.50	73.11	0.10	-80.00	7.33	66.34	7.96	37.80	
314.00	20.16	41.00	17.34	22.96	31.64	18.33	68.65	-0.10	-56.00	6.43	64.32	7.96	36.60	
327.00	20.32	40.04	17.34	23.62	31.64	18.33	67.11	0.00	-25.00	6.43	63.70	7.96	35.30	
338.00	20.32	39.39	17.34	23.62	31.64	18.50	64.48	-0.10	76.00	5.38	63.70	7.96	34.30	Furnace fan turns off
349.00	20.32	38.91	17.34	23.95	31.64	18.50	63.39	-0.10	-126.00	4.98	65.41	7.79	33.20	
367.00	20.51	38.29	17.36	23.97	31.33	18.68	59.52	0.10	25.00	8.38	52.15	7.81	32.50	
381.00	20.34	37.96	17.36	23.48	31.33	18.68	54.98	-0.10	-33.00	7.61	48.51	8.15	32.10	
394.00	20.01	37.48	17.36	22.82	31.17	18.68	50.41	-0.10	-6.00	8.63	38.29	8.15	31.80	
405.00	19.84	37.00	17.36	22.32	31.17	18.35	48.51	0.20	-25.00	8.38	38.29	7.98	31.30	
416.00	19.84	36.51	17.36	22.32	31.17	18.35	47.08	-0.10	14.00	8.38	37.00	8.32	31.00	
428.00	19.37	36.37	17.38	22.18	31.02	18.37	45.19	-0.10	-3.00	7.04	39.27	8.17	30.50	
442.00	19.53	35.89	17.38	22.67	31.02	18.37	46.78	0.00	0.00	5.75	44.24	8.00	29.90	
455.00	19.86	35.73	17.38	23.17	31.02	18.54	47.42	0.20	-6.00	5.75	47.26	7.83	29.40	
466.00	20.03	35.73	17.38	23.17	31.19	18.70	47.10	-0.10	-80.00	6.74	46.78	8.17	29.20	
477.00	20.03	35.56	17.38	23.17	31.02	18.54	46.31	-0.10	-376.00	4.98	48.05	8.51	28.90	

DHW VENT CONNECTOR TEST RUN 9
26/02/87 sebshouse DURATION=480 s House Pressure: -1 Pa

Configuration: T-merge into furnace vent connector, 2.1m from furnace dilution

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
1.00	25.56	26.71	17.14	27.36	32.90	16.64	22.76	-0.20	-183.00	6.10	18.30	7.76	19.80	Stable venting
17.00	25.39	26.71	17.14	26.71	32.74	16.64	22.43	-0.20	-126.00	6.43	18.30	7.76	20.30	
28.00	25.07	26.71	17.14	26.38	32.58	16.64	22.43	0.00	-33.00	6.43	18.46	7.76	20.60	
39.00	24.57	26.71	17.14	26.21	32.41	16.64	22.43	-0.10	105.00	6.74	18.30	7.76	20.80	
50.00	24.41	26.54	17.14	26.38	32.41	16.64	22.43	0.00	-161.00	5.75	18.46	7.76	20.90	
62.00	25.07	26.71	17.14	71.85	95.86	16.47	36.30	0.10	31.00	8.38	18.13	7.76	21.60	at 60s, start DHW, stable
77.00	34.20	28.51	17.14	143.70	143.27	16.47	46.08	0.10	6.00	8.13	18.13	7.93	23.30	venting continues
88.00	44.00	29.81	17.14	170.79	162.28	16.47	51.46	0.00	-31.00	8.13	18.13	7.76	24.70	
99.00	54.14	30.79	17.14	187.03	172.05	16.30	53.99	0.00	0.00	8.13	18.13	7.93	25.90	
111.00	64.76	31.60	17.14	199.59	178.16	16.30	54.93	0.00	-25.00	8.13	18.13	7.93	26.90	
122.00	76.11	32.07	17.12	209.77	182.58	16.28	56.48	0.00	-6.00	8.38	18.11	8.08	28.10	
137.00	87.17	32.72	17.12	215.42	185.49	16.28	58.98	0.00	0.00	8.13	18.11	8.08	28.90	
148.00	95.99	33.21	17.12	219.56	186.46	16.28	61.32	0.00	-61.00	8.38	18.11	8.08	29.60	
159.00	103.40	33.69	17.12	221.76	189.08	16.28	63.50	-0.10	-124.00	8.63	17.95	8.08	30.30	
171.00	110.30	34.34	17.12	219.69	189.78	16.45	69.37	-0.10	-47.00	9.54	17.95	8.08	31.20	
182.00	115.86	34.52	17.14	216.68	189.52	16.47	72.92	0.10	-834.00	9.32	17.80	7.93	31.90	
197.00	121.52	35.01	17.14	218.75	191.04	16.30	73.38	0.10	11.00	9.32	17.80	7.76	32.70	
208.00	125.42	35.33	17.14	220.26	190.62	16.30	74.45	0.00	163.00	9.09	17.97	7.76	32.80	
219.00	129.30	35.65	17.14	223.16	191.86	16.30	75.52	-0.10	-36.00	9.32	17.80	7.59	33.20	
231.00	132.59	36.14	17.14	221.23	191.17	16.30	77.05	0.10	-124.00	8.86	17.80	7.76	33.50	
242.00	134.31	36.14	17.14	171.49	147.24	16.30	66.15	0.10	0.00	7.88	17.47	7.93	33.20	DHW off at 240s
257.00	129.15	34.52	17.14	130.16	113.53	16.14	57.91	-0.10	14.00	7.04	17.80	8.10	31.90	
268.00	123.69	33.71	17.14	111.49	97.20	16.14	52.88	0.00	-573.00	6.74	17.97	8.10	31.20	
279.00	117.75	32.90	17.14	99.72	87.04	16.14	49.25	0.00	25.00	6.74	18.13	8.10	30.30	
291.00	111.49	32.58	17.14	91.09	80.09	16.30	46.87	0.00	51.00	6.74	18.13	8.10	29.60	
302.00	104.59	32.09	17.14	83.42	73.53	16.30	44.48	0.00	-86.00	7.61	18.30	8.10	28.90	
317.00	97.79	31.76	17.14	75.06	69.08	16.14	44.00	-0.10	-193.00	7.61	17.97	7.93	28.40	
328.00	91.39	31.44	17.14	70.00	65.22	16.14	42.73	-0.10	-78.00	6.43	17.97	7.93	27.90	
339.00	85.98	31.11	17.14	65.84	62.27	16.14	41.77	0.00	-42.00	6.74	18.13	8.10	27.40	
351.00	81.00	30.95	17.14	61.96	59.31	16.30	40.64	0.00	-902.00	6.43	18.13	8.10	27.00	
368.00	73.40	30.65	17.15	57.46	55.42	16.66	37.77	0.00	0.00	6.43	18.32	7.95	26.30	
383.00	68.64	30.32	17.16	54.63	53.22	17.16	36.80	0.00	-3.00	6.43	18.15	8.12	26.10	
394.00	64.93	30.16	17.16	52.27	51.80	16.66	36.00	0.10	-3.00	6.43	18.15	8.12	25.80	
405.00	61.67	29.99	17.16	50.22	50.38	16.49	35.19	0.00	0.00	6.43	18.15	7.95	25.50	
416.00	58.40	29.83	17.16	48.00	48.95	16.32	34.22	0.00	0.00	6.10	18.32	7.95	25.20	
428.00	55.11	29.83	17.16	45.94	47.21	16.32	32.76	0.00	-3.00	6.43	18.15	7.78	25.00	
443.00	51.96	29.67	17.16	43.23	46.10	16.49	31.46	0.10	-6.00	6.43	18.15	7.78	24.70	
454.00	49.43	29.34	17.16	40.98	44.98	16.49	29.83	0.00	25.00	6.74	17.99	7.78	24.50	
465.00	46.89	29.18	17.16	39.86	44.18	16.49	29.18	0.00	20.00	6.43	18.15	7.78	24.20	
476.00	44.82	29.02	17.16	38.74	43.39	16.32	28.36	-0.10	-6.00	6.10	18.15	7.78	24.10	

DHW VENT CONNECTOR TEST RUN 10
26/02/87 sebshouse DURATION=480 s House Pressure: -5 Pa

Configuration: T-merge into furnace vent connector, 2.1m from furnace dilution

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
0.00	21.40	25.02	16.93	26.83	30.09	17.26	22.72	0.10	-45.00	3.52	26.34	7.55	17.40	Venting unstable
16.00	21.57	25.02	16.89	26.17	30.09	18.59	23.05	0.00	-105.00	4.07	30.42	8.05	15.70	Velocity measurement invalid
27.00	21.57	25.02	16.89	26.34	30.09	19.08	22.72	0.10	3.00	4.55	29.60	8.05	15.00	until 360 s.
38.00	22.72	25.19	16.93	27.15	30.09	18.75	23.38	0.10	3.00	4.55	26.34	7.88	15.80	
49.00	23.05	25.19	16.93	27.65	30.09	19.42	23.38	0.10	-25.00	4.07	28.95	8.05	15.60	
60.00	23.03	25.17	16.91	66.86	77.90	18.73	30.07	0.10	-132.00	7.61	25.82	8.03	16.80	Start DHW, stable venting
74.00	29.75	26.15	16.91	141.94	136.39	18.07	41.22	0.00	-351.00	7.61	21.71	7.69	19.50	
87.00	40.74	27.30	16.91	179.36	161.39	17.90	49.82	0.10	-58.00	6.74	23.69	7.69	20.50	
98.00	51.72	28.28	16.94	199.26	171.71	18.07	52.67	-0.10	0.00	7.04	22.54	7.86	21.80	
109.00	62.52	29.10	16.91	214.84	177.97	17.74	57.22	0.00	-151.00	7.88	21.88	7.86	23.00	
121.00	72.88	29.93	16.96	218.85	182.70	17.09	53.47	0.00	355.00	7.88	20.57	7.55	24.70	
135.00	83.68	30.42	16.89	226.70	186.58	16.93	55.20	-0.10	-3.00	7.88	20.41	7.71	25.80	
148.00	94.04	31.23	16.89	224.22	188.79	16.76	56.93	-0.10	59.00	7.88	19.58	7.55	27.30	
159.00	101.75	31.40	16.93	234.16	190.17	16.76	58.02	-0.10	-80.00	8.13	19.91	7.88	27.70	
170.00	108.96	31.72	16.93	235.13	191.83	16.76	57.08	0.00	0.00	8.13	19.75	7.71	28.40	
182.00	116.26	32.21	16.89	239.41	193.48	16.93	58.34	0.00	-379.00	7.88	19.75	7.71	28.90	
196.00	122.49	32.53	16.93	245.37	194.73	16.93	60.36	0.00	20.00	7.33	20.08	7.55	29.10	
209.00	129.12	33.18	16.93	250.50	196.38	16.93	64.72	-0.10	-64.00	8.38	19.91	7.88	29.50	
220.00	133.84	33.35	16.96	249.39	196.38	16.76	63.01	0.00	-287.00	7.88	19.75	8.05	29.90	
231.00	137.84	33.67	16.93	248.14	196.80	16.43	61.77	0.10	0.00	8.63	19.58	8.05	30.70	
243.00	141.14	34.36	16.97	241.66	197.93	16.80	62.43	0.10	-33.00	7.61	19.62	7.92	31.30	At 250s, stopped DHW. Venting
257.00	141.71	34.03	16.97	185.09	144.97	16.80	56.65	0.00	-6.00	4.98	19.46	7.75	31.10	unstable
270.00	138.58	33.06	16.97	140.43	112.51	16.47	51.93	-0.10	-58.00	2.03	19.79	7.92	30.30	
281.00	134.45	31.92	17.00	123.54	96.75	16.80	49.88	0.00	0.00	ERR	20.78	7.75	29.40	
292.00	129.29	31.60	16.97	111.78	86.28	16.97	49.88	0.00	-349.00	2.03	22.43	7.59	28.40	
304.00	122.54	30.97	16.99	103.28	78.28	17.32	49.42	0.00	-11.00	4.55	24.43	7.44	27.20	
318.00	115.73	30.80	16.99	94.39	72.63	17.65	46.73	-0.10	0.00	9.54	21.95	7.78	26.90	
331.00	108.43	30.64	16.99	82.98	67.86	17.15	44.02	-0.10	-25.00	6.10	20.63	7.94	26.80	
342.00	102.40	30.15	16.99	77.37	64.31	17.15	42.26	0.10	-42.00	6.74	19.97	7.61	26.70	
353.00	96.03	29.99	16.95	70.94	61.20	16.99	40.50	0.10	-36.00	6.10	19.97	7.44	26.30	
371.00	87.80	29.66	16.99	68.33	56.67	17.15	38.73	0.00	-3.00	6.10	20.80	7.61	25.30	
384.00	82.98	29.50	17.02	59.95	54.32	16.99	38.09	0.10	0.00	6.43	19.14	7.78	25.60	
397.00	76.76	29.17	17.02	54.94	51.95	16.49	37.77	-0.10	74.00	6.10	18.81	7.78	25.60	
408.00	71.71	29.01	16.99	52.90	50.06	16.49	36.32	-0.10	28.00	4.98	19.97	7.61	25.00	
419.00	67.86	28.85	16.99	51.95	48.47	16.49	35.51	-0.10	-161.00	5.75	19.81	7.78	24.70	DHW and furnace venting stable.
431.00	64.17	28.70	17.01	49.29	46.75	16.34	35.20	0.10	0.00	5.38	19.66	7.80	24.50	
444.00	60.75	28.38	17.01	48.33	45.16	16.84	33.75	0.10	-86.00	4.98	20.65	7.80	24.00	
457.00	57.78	28.38	17.04	47.70	43.88	16.84	33.42	0.00	0.00	4.98	20.98	7.80	23.60	
468.00	55.28	28.21	17.04	46.91	42.60	17.17	32.61	0.10	68.00	4.98	21.97	7.80	23.10	Venting unstable again.
479.00	53.08	28.21	17.04	45.31	41.48	17.17	32.29	0.10	-25.00	5.38	21.31	7.80	23.00	

DHW VENT CONNECTOR TEST RUN 11
26/02/87 sebshouse DURATION=480 s House Pressure: -7 Pa

Configuration: T-merge into furnace vent connector, 2.1m from furnace dilution

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
1.00	23.26	25.72	17.10	21.61	29.00	18.80	19.79	0.00	0.00	2.88	19.13	7.93	10.40	Stable backdrafting of DHW
16.00	22.76	25.72	17.10	21.44	29.00	18.80	19.79	0.10	0.00	2.03	19.29	8.60	9.70	and furnace
27.00	22.60	25.72	17.10	21.11	29.00	18.46	19.79	0.00	37.00	2.03	19.13	8.10	9.20	
38.00	22.43	25.72	17.14	20.95	28.83	18.30	19.79	0.10	355.00	0.00	18.96	8.10	8.90	
49.00	22.10	25.72	17.10	20.62	28.83	18.80	19.62	-0.10	-6.00	0.00	18.80	8.77	8.50	
61.00	21.77	25.56	17.10	20.12	28.34	18.46	18.96	0.10	-3.00	2.03	18.30	9.11	8.10	
76.00	21.61	25.56	17.10	19.79	57.91	18.96	18.80	0.00	-530.00	3.52	18.13	8.77	7.90	Start DHW @ 75s, backdrafting
87.00	21.61	25.56	17.10	20.12	123.97	19.13	18.46	0.10	0.00	2.88	18.13	8.26	7.60	stable
98.00	21.61	25.39	17.10	59.94	153.72	19.62	18.46	-0.20	-3.00	6.10	23.26	8.26	7.80	
110.00	25.72	25.56	17.10	154.99	167.31	26.05	20.12	-0.10	-11.00	4.55	32.74	8.10	7.90	
121.00	42.75	25.74	17.16	193.81	177.34	24.59	20.64	0.00	-33.00	6.10	36.00	8.12	7.90	at 125s, stable venting of DHW,
136.00	49.43	25.74	17.12	224.14	181.09	25.41	30.32	0.00	14.00	6.10	41.63	7.95	8.20	furnace backdrafting. Short
147.00	58.86	26.23	17.16	240.30	184.55	28.36	43.23	0.00	42.00	7.04	42.75	7.78	8.60	circuit
158.00	64.47	27.87	17.16	246.95	186.77	26.40	58.86	0.10	14.00	7.04	36.80	7.78	9.60	
170.00	75.39	29.83	17.16	252.23	189.26	25.09	72.02	0.00	0.00	6.43	34.22	7.78	10.60	
181.00	89.49	29.87	17.20	263.00	192.88	28.56	66.51	0.10	-58.00	7.61	41.82	7.82	10.80	
196.00	101.11	31.50	17.20	256.16	192.74	23.98	74.20	0.00	-67.00	7.61	29.87	7.99	17.30	
207.00	108.47	32.64	17.16	249.48	194.12	21.17	67.44	-0.10	6.00	7.88	23.81	7.99	23.00	Furnace venting stable. No short
218.00	115.04	32.80	17.20	252.26	194.40	19.68	68.37	0.00	-88.00	8.13	22.66	7.82	24.00	circuit
230.00	119.40	33.45	17.16	248.09	194.26	18.36	67.13	-0.10	-108.00	8.63	20.84	7.82	25.60	
241.00	123.45	33.77	17.20	233.83	194.40	17.36	67.75	0.20	-105.00	7.33	19.85	7.99	25.30	
256.00	128.34	33.61	17.23	220.86	160.09	19.68	74.35	0.10	-42.00	5.38	23.32	7.82	21.80	Stopped DHW, furnace backdrafting
267.00	130.21	32.47	17.23	176.55	122.00	28.24	64.35	0.00	31.00	3.52	38.13	8.66	18.50	immediately
278.00	129.06	30.85	17.23	160.51	101.40	26.60	51.52	0.10	14.00	2.88	39.10	8.33	15.60	DHW backdrafting
290.00	127.19	29.71	17.23	144.88	88.89	25.45	41.34	0.10	0.00	4.07	36.20	8.16	13.40	
301.00	123.75	28.91	17.25	126.35	79.25	30.38	35.73	-0.10	-20.00	2.03	40.72	8.18	11.50	
316.00	118.84	28.42	17.22	118.98	73.00	28.09	31.68	0.10	-894.00	2.88	35.57	8.35	10.60	
327.00	114.04	28.09	17.25	110.83	68.85	26.62	29.07	-0.10	-28.00	4.55	33.63	8.35	9.80	
338.00	109.37	28.09	17.22	101.27	65.30	29.07	28.58	-0.10	-17.00	2.03	34.28	8.35	9.50	
350.00	104.67	27.93	17.25	95.34	61.88	27.44	27.28	0.00	3.00	4.98	32.82	8.35	9.30	
367.00	97.27	28.26	17.25	83.49	57.20	26.29	37.02	0.00	-28.00	2.88	34.76	8.68	9.50	
382.00	92.36	28.26	17.22	78.95	54.69	26.29	36.38	-0.10	-20.00	4.07	33.95	8.35	9.20	
393.00	88.46	28.09	17.25	76.05	52.80	27.11	34.28	0.00	-3.00	2.88	33.47	8.35	8.70	
404.00	84.40	27.93	17.25	73.15	50.75	27.44	31.19	0.00	-490.00	2.88	32.65	8.18	8.60	
416.00	81.22	27.60	17.25	71.46	49.33	26.13	28.91	0.00	11.00	2.88	30.22	8.18	8.40	
427.00	76.83	27.46	17.24	65.16	47.60	23.85	25.66	0.00	0.00	0.00	27.13	8.70	8.10	
442.00	72.25	27.13	17.24	55.65	46.01	22.53	23.52	0.10	355.00	4.07	25.33	9.21	8.00	
453.00	68.87	27.13	17.24	56.91	45.06	23.85	23.03	-0.10	-102.00	2.88	26.48	9.21	7.90	
464.00	66.55	26.80	17.24	52.35	44.10	22.70	22.53	-0.10	-14.00	0.00	24.84	8.87	7.80	
475.00	63.45	26.64	17.24	46.65	43.14	21.54	21.54	0.10	-341.00	4.07	23.69	8.37	7.80	

DHW VENT CONNECTOR TEST RUN 12
26/02/87 sebshouse DURATION=480 s House Pressure: -5 Pa

Configuration: T-merge into furnace vent connector, 2.1m from furnace dilution

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
0.00	19.99	24.94	17.34	22.14	26.58	19.33	21.81	0.10	-14.00	4.55	23.95	8.13	12.40	DHW and furnace venting unstable
16.00	19.99	24.94	17.34	22.96	26.58	18.50	22.14	-0.10	-20.00	4.07	23.62	8.13	13.50	
27.00	19.99	24.94	17.34	23.78	26.58	18.50	22.30	0.10	3.00	4.07	25.43	7.96	13.90	
38.00	19.99	25.26	17.34	24.44	26.41	18.50	22.80	-0.10	-126.00	4.07	26.41	8.30	14.20	
49.00	20.16	25.26	17.34	23.95	26.41	19.99	22.80	-0.10	0.00	4.55	27.23	7.96	13.90	
60.00	20.16	25.26	17.34	23.95	26.41	35.85	26.25	-0.10	76.00	4.07	113.27	8.30	14.80	Start furnace.
74.00	20.32	26.58	17.37	24.77	26.58	30.98	58.25	0.10	0.00	4.55	158.25	8.30	18.00	At 75s, furnace venting stable
87.00	20.32	30.50	17.34	24.11	26.58	26.25	77.23	0.20	0.00	5.38	164.83	7.96	23.50	At 80s, DHW venting stable.
98.00	20.32	33.75	17.34	23.46	26.41	23.62	87.07	0.10	-86.00	4.98	171.24	8.13	27.30	No short circuit occurred.
109.00	20.49	35.85	17.34	23.46	26.41	22.30	93.96	0.10	6.00	4.98	181.52	8.30	29.10	
121.00	20.47	37.60	17.32	23.44	26.39	21.62	100.92	-0.10	-554.00	5.75	186.76	8.45	30.60	
134.00	20.47	39.05	17.32	22.94	26.39	20.30	105.93	0.20	-31.00	6.43	182.33	8.45	32.30	Furnace fan turns on.
147.00	20.47	40.02	17.32	22.78	26.39	19.97	109.45	-0.10	-42.00	5.75	189.25	8.45	33.80	
158.00	20.30	40.82	17.32	22.78	26.39	20.14	112.09	-0.10	-183.00	5.38	197.67	8.28	34.90	
169.00	20.30	41.46	17.32	22.78	26.39	20.30	115.15	0.10	-20.00	5.38	197.67	8.45	36.10	
181.00	20.47	41.94	17.32	22.61	26.39	20.30	118.20	0.10	-25.00	5.38	202.09	8.45	37.10	
194.00	20.47	42.74	17.32	22.78	26.39	20.96	121.10	0.10	-45.00	5.38	205.39	8.95	38.00	
207.00	20.47	43.38	17.32	22.78	26.39	20.96	123.99	0.00	-17.00	6.10	198.91	8.78	39.30	
218.00	20.47	44.34	17.32	22.28	26.39	20.30	126.29	0.10	6.00	6.10	196.16	8.45	40.70	
229.00	20.47	45.13	17.28	22.12	26.39	19.80	125.57	-0.20	-143.00	7.33	182.89	8.11	42.60	
241.00	20.34	45.97	17.36	21.83	26.43	19.18	124.45	0.00	0.00	7.04	179.04	7.98	43.90	
255.00	20.34	46.29	17.36	21.99	26.43	19.35	127.76	0.10	28.00	5.75	199.91	8.32	44.00	
268.00	20.34	46.76	17.32	21.99	26.43	19.18	127.76	-0.10	-3.00	8.13	180.56	7.98	45.10	
279.00	20.34	47.40	17.36	21.83	26.43	19.18	129.20	-0.20	0.00	7.88	183.06	7.98	45.70	
290.00	20.34	48.03	17.36	21.83	26.43	19.18	129.49	-0.10	99.00	6.43	195.22	7.98	46.10	
302.00	20.36	48.21	17.38	22.18	26.45	20.19	133.09	-0.10	3.00	6.10	204.75	8.34	45.80	
316.00	20.36	48.69	17.34	22.34	26.45	20.36	134.80	0.10	45.00	6.10	204.48	8.34	46.10	
329.00	20.36	49.00	17.34	22.34	26.29	20.36	135.94	0.10	-3.00	6.43	205.86	8.00	46.30	
340.00	20.53	49.64	17.38	22.67	26.29	20.36	137.37	0.00	-3.00	6.74	178.64	8.17	46.30	
351.00	20.36	48.85	17.34	22.18	26.29	20.03	111.85	0.10	-17.00	6.74	118.98	8.17	45.60	Furnace turned off.
369.00	20.59	44.61	17.44	22 40	26.35	19.59	94.79	0.10	11.00	6.10	99.84	8.23	42.60	
382.00	20.59	43.02	17.47	22.40	26.35	19.26	87.31	-0.10	-61.00	5.38	90.91	7.89	41.10	
395.00	20.59	41.74	17.44	22.73	26.35	18.76	82.03	0.10	-97.00	5.38	83.84	8.23	39.70	
406.00	20.59	40.77	17.44	22.73	26.35	18.60	77.02	0.20	0.00	5.38	79.75	8.06	38.40	
417.00	20.59	39.81	17.44	23.06	26.35	18.76	73.81	-0.10	91.00	4.07	82.03	8.40	36.90	
429.00	20.97	38.90	17.52	23.93	26.40	18.81	71.56	-0.10	0.00	4.55	78.43	8.28	35.30	
442.00	20.97	38.25	17.49	23.93	26.07	19.48	68.17	0.10	-20.00	4.55	76.45	8.45	34.00	
455.00	20.97	37.61	17.49	23.77	26.40	19.48	64.77	-0.10	14.00	4.98	66.32	8.62	33.50	
466.00	21.13	37.29	17.49	23.60	26.40	19.48	62.60	-0.10	0.00	5.38	65.55	8.62	32.80	
477.00	21.13	36.80	17.49	23.11	26.40	19.15	59.64	-0.10	-6.00	4.98	62.13	8.62	32.50	

DHW VENT CONNECTOR TEST RUN 13
26/02/87 sebshouse DURATION=480 s House Pressure: -7 Pa

Configuration: T-merge into furnace vent connector, 2.1m from furnace dilution

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
1.00	23.19	29.75	17.74	27.13	26.64	29.75	27.95	0.10	-124.00	3.52	54.40	8.71	10.00	DHW and furnace backdrafting.
16.00	23.19	29.91	17.74	28.12	26.64	26.64	30.40	0.00	-137.00	3.52	58.47	8.71	10.20	
27.00	23.03	29.91	17.74	30.40	26.64	33.00	30.40	0.10	-61.00	2.03	48.87	9.21	9.70	
38.00	23.19	29.91	17.74	28.61	26.32	31.70	28.44	0.00	-280.00	2.88	36.08	8.87	9.20	
49.00	23.19	29.59	17.74	26.97	26.64	34.14	26.97	0.10	56.00	2.03	31.21	8.54	9.00	
60.00	23.19	29.42	17.74	25.66	26.32	52.82	25.17	0.00	51.00	ERR	27.79	8.71	8.70	Start furnace.Slight shortcircuit
74.00	23.03	28.93	17.74	24.02	25.99	76.07	23.85	0.10	0.00	ERR	25.33	8.54	8.50	out DHW; Furnace venting unstable
87.00	23.03	28.77	17.74	23.03	25.82	87.88	22.70	0.00	25.00	0.00	24.51	8.37	8.50	
98.00	22.70	28.77	17.74	22.70	25.99	106.30	22.53	0.00	-3.00	ERR	24.35	8.54	8.40	
109.00	22.70	28.77	17.74	22.53	25.82	106.60	22.21	0.00	-3.00	ERR	24.02	8.71	8.10	
120.00	22.74	28.65	17.78	22.41	26.03	133.43	23.89	0.00	-3.00	2.88	145.80	8.41	8.50	Furnace fan comes on.
134.00	22.74	30.28	17.81	28.65	26.19	88.37	61.94	-0.10	-36.00	3.52	208.39	8.41	12.30	
147.00	22.57	34.98	17.78	27.34	26.35	63.18	88.52	0.00	0.00	4.55	213.90	8.24	22.50	
158.00	22.57	38.05	17.81	26.19	26.35	49.86	99.11	0.10	45.00	4.07	221.34	8.58	27.00	
169.00	22.57	39.82	17.81	26.19	26.35	41.42	107.51	0.10	0.00	6.10	216.11	8.75	29.90	
181.00	22.59	41.60	17.83	24.90	26.37	34.84	112.80	0.00	-11.00	5.75	208.41	8.93	31.80	Stable venting of DHW and furnace
194.00	22.43	42.56	17.76	24.41	26.37	31.27	117.17	0.10	0.00	4.55	219.84	8.93	31.40	
207.00	22.43	43.36	17.76	24.57	26.37	29.81	119.49	0.00	-214.00	4.55	227.01	8.43	31.60	
218.00	22.43	44.32	17.80	25.06	26.37	28.50	123.25	0.20	-3.00	5.38	217.78	8.26	33.00	
229.00	22.26	45.44	17.76	24.41	26.37	27.19	126.42	-0.10	11.00	4.98	215.60	8.60	35.00	
241.00	22.45	45.93	17.82	24.26	26.39	25.74	114.13	-0.10	-3.00	4.55	150.50	8.79	36.00	Furnace shut off.
254.00	22.45	43.06	17.85	24.42	26.39	24.26	99.88	0.10	0.00	4.07	126.87	8.62	35.00	
267.00	22.45	40.82	17.85	24.92	26.39	23.27	91.55	-0.10	-45.00	4.07	115.29	8.95	34.30	
278.00	22.45	39.70	17.85	25.25	26.39	22.45	86.00	0.00	-759.00	3.52	112.53	8.62	33.20	
289.00	22.45	38.73	17.85	25.90	26.39	22.45	82.38	0.00	0.00	3.52	106.67	8.45	31.90	
301.00	22.47	38.11	17.87	26.09	26.25	22.14	78.30	-0.10	3.00	3.52	100.05	8.98	31.10	
314.00	22.30	37.46	17.84	26.25	26.41	22.30	74.03	0.00	14.00	3.52	94.11	9.65	30.00	Venting unstable.
327.00	22.30	36.98	17.84	26.25	26.41	21.81	70.81	0.10	-14.00	5.38	81.64	9.31	29.70	
338.00	22.30	36.98	17.84	25.10	26.41	21.31	64.95	0.10	42.00	4.07	71.57	8.64	30.10	Furnace fan shuts off.
349.00	22.30	36.34	17.84	24.94	26.41	20.82	63.08	-0.20	17.00	4.07	70.19	8.30	30.00	
367.00	22.36	35.75	17.90	26.47	26.47	21.37	60.81	-0.10	-3.00	4.07	78.50	8.03	27.70	
381.00	22.53	35.26	17.90	27.29	26.31	21.37	60.03	0.00	0.00	2.88	78.81	7.86	26.40	
394.00	22.53	34.94	17.90	33.64	26.31	25.49	57.84	0.00	-11.00	2.88	81.84	7.86	23.40	
405.00	22.69	34.29	17.90	36.72	26.47	24.18	57.84	-0.10	-156.00	3.52	78.66	7.86	22.20	
416.00	23.19	34.29	17.86	32.83	26.47	23.68	57.22	0.00	-28.00	2.88	76.98	7.69	21.70	
428.00	23.19	34.29	17.86	30.56	26.47	22.69	56.59	0.00	355.00	3.52	75.15	8.36	21.70	
442.00	23.35	34.13	17.90	32.51	26.47	22.53	55.33	0.00	25.00	2.03	77.13	8.70	19.70	
455.00	23.52	33.64	17.90	40.58	26.47	40.42	49.18	0.00	-31.00	2.03	70.25	9.37	17.00	
466.00	24.01	33.16	17.90	38.17	26.47	45.85	44.74	-0.10	0.00	2.88	69.32	9.04	15.30	
477.00	24.18	32.83	17.90	37.20	26.47	42.50	45.69	-0.10	0.00	2.03	71.48	8.87	14.10	

DHW VENT CONNECTOR TEST RUN 14
86/02/87 sebshouse DURATION=480 s House Pressure: -7 Pa

Configuration: Insulated, direct connection to chimney, 0.2m above and perpendicular to the furnace vent connector.

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
1.00	19.06	25.84	17.45	19.57	18.74	18.41	20.40	0.00	-6.00	ERR	19.41	8.55	10.20	Furnace venting stable, DHW
17.00	19.08	25.67	17.45	19.41	18.41	20.07	19.41	-0.20	0.00	ERR	18.74	8.89	9.20	unstable, velocity invalid
28.00	19.08	25.67	17.45	19.08	18.41	19.57	19.41	0.10	0.00	ERR	19.08	8.89	8.70	because tubing melted after
39.00	19.08	25.84	17.45	19.24	18.41	19.57	19.57	-0.20	-6.00	0.00	19.24	8.55	8.20	DHW start
50.00	19.08	25.84	17.45	19.24	18.58	20.40	19.57	0.00	355.00	4.98	21.89	8.21	8.50	DHW venting stable.
62.00	19.04	25.80	17.38	18.21	19.04	19.04	20.53	0.00	-475.00	7.04	20.53	8.17	11.50	
77.00	28.09	25.96	17.38	59.07	91.15	18.37	21.19	0.30	149.00	6.43	22.18	8.00	13.40	At 70s, start DHW.
88.00	38.95	27.27	17.38	83.03	132.51	18.21	22.01	0.00	-58.00	7.04	21.85	8.00	16.40	
99.00	46.15	27.27	17.38	90.71	153.79	17.54	22.01	0.00	-3.00	6.74	21.02	8.17	19.80	
111.00	57.04	27.76	17.34	24.98	166.81	17.38	22.01	-0.10	-50.00	9.96	20.19	8.17	23.00	
122.00	65.58	28.23	17.36	22.98	174.18	16.86	21.66	0.10	-280.00	7.88	19.84	8.15	25.20	
137.00	79.53	28.40	17.36	23.80	179.45	16.69	21.83	0.10	-3.00	7.88	20.17	8.32	26.60	
148.00	89.94	28.23	17.36	24.46	181.26	16.52	21.99	0.20	62.00	7.88	20.51	8.82	27.30	
159.00	99.62	28.40	17.36	24.79	188.18	16.86	22.16	-0.10	-14.00	8.38	21.00	8.99	28.40	
171.00	107.73	28.23	17.36	24.79	191.63	16.86	22.16	0.20	225.00	9.54	20.01	8.49	29.90	
182.00	115.78	28.58	17.38	24.81	194.27	17.21	22.01	-0.10	6.00	8.86	20.53	8.85	30.80	
197.00	125.48	28.42	17.34	24.65	193.86	17.21	22.01	-0.10	0.00	12.70	19.20	8.51	32.70	
208.00	127.93	29.23	17.38	23.82	194.63	16.71	21.68	-0.10	-148.00	12.70	18.70	8.34	33.60	
219.00	130.37	30.21	17.38	23.82	195.79	16.71	21.35	0.00	0.00	10.17	19.04	8.34	33.80	
231.00	135.23	30.05	17.34	24.81	196.34	16.71	21.68	-0.10	3.00	9.09	19.37	8.34	34.00	
242.00	140.62	29.54	17.36	121.13	195.91	16.69	21.83	0.20	-282.00	11.68	19.18	8.15	34.90	
257.00	143.89	29.54	17.36	32.79	196.60	16.69	21.66	-0.10	0.00	8.13	19.18	8.15	34.90	At 250s, DHW shut off.
268.00	148.13	29.86	17.32	30.52	197.43	16.52	21.83	0.20	17.00	7.04	19.84	8.32	34.50	
279.00	152.78	29.86	17.36	29.86	196.74	16.69	21.99	-0.20	-228.00	6.43	20.17	8.82	34.40	
291.00	156.86	30.03	17.36	29.37	196.74	16.52	22.16	0.10	-172.00	6.10	20.01	8.32	34.90	
302.00	158.68	30.03	17.39	28.72	195.77	16.52	21.83	-0.10	-45.00	4.55	19.51	8.49	35.20	
317.00	161.07	30.52	17.39	28.56	197.71	16.52	21.83	0.10	-343.00	4.07	19.35	8.15	35.80	
328.00	163.58	30.84	17.39	28.72	198.12	16.52	21.83	0.10	-33.00	3.52	19.18	8.32	36.10	
339.00	165.68	30.52	17.36	29.21	197.57	16.52	21.99	-0.10	338.00	2.88	20.01	8.32	35.50	
351.00	168.75	30.52	17.39	29.54	197.84	16.52	22.16	0.00	11.00	2.88	20.34	8.82	35.30	
369.00	173.07	30.84	17.36	29.54	197.71	16.52	22.16	-0.10	196.00	2.88	20.17	8.99	35.60	
384.00	171.26	30.35	17.36	25.78	151.94	16.69	21.99	-0.20	-526.00	2.88	19.51	8.49	36.10	
395.00	164.56	30.35	17.36	23.15	115.33	16.69	21.83	0.10	0.00	2.88	19.18	8.32	35.10	
406.00	157.70	30.52	17.36	22.32	95.32	16.52	21.83	-0.20	-11.00	2.88	20.17	8.15	33.90	
418.00	151.52	30.35	17.39	22.16	83.32	17.19	22.16	0.10	-169.00	2.88	24.46	8.49	31.60	Furnace venting unstable.
429.00	145.32	31.19	17.38	22.01	73.76	17.54	22.84	0.10	-20.00	2.88	26.94	8.51	29.20	
444.00	139.22	31.35	17.38	21.68	66.99	18.04	23.50	0.00	-31.00	2.88	24.81	8.51	28.10	
455.00	132.08	31.02	17.34	20.36	62.50	17.21	22.67	-0.10	0.00	2.88	21.35	8.17	28.80	
466.00	125.34	30.54	17.38	25.63	58.29	16.88	22.34	0.10	-485.00	2.88	20.53	8.34	28.50	
478.00	119.27	30.37	17.38	21.85	54.84	17.71	22.34	0.00	-56.00	2.88	25.80	8.51	25.90	
478.00	119.27	30.37	17.00							0.00				
0.10	0.20	20.53	8.34	28.50										
478.00	0.00													

DHW VENT CONNECTOR TEST RUN 15
26/02/87 sebshouse DURATION=480 s House Pressure: -7 Pa

Configuration: Flexible, direct connection to chimney, 0.2m above and perpendicular to the furnace vent connector.

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
1.00	18.11	24.55	17.12	17.28	20.10	19.77	20.60	0.10	-148.00	3.52	20.27	8.08	10.60	DHW and furnace backdrafting.
17.00	18.11	24.72	17.15	17.28	20.27	20.60	20.76	0.00	-67.00	2.88	20.10	8.58	9.80	Velocity invalid
28.00	18.11	24.55	17.15	17.45	19.77	19.77	19.94	-0.10	-31.00	3.52	19.11	8.58	9.10	
39.00	18.11	24.55	17.15	17.12	19.11	19.11	19.27	-0.10	-72.00	3.52	18.78	8.75	8.50	
50.00	18.11	24.55	17.15	17.12	18.78	18.78	18.78	0.10	34.00	3.52	18.28	8.75	8.10	
62.00	17.92	24.36	17.12	16.92	65.02	18.25	18.08	0.00	-31.00	3.52	18.08	8.55	7.80	At 60s, started DHW.
77.00	28.29	24.36	17.09	20.73	127.10	18.75	23.21	0.10	-285.00	3.52	20.73	8.55	7.60	
88.00	49.20	24.52	17.12	20.90	152.84	19.08	25.35	0.10	-3.00	3.52	22.38	8.89	7.50	
99.00	46.51	24.52	17.12	18.91	162.38	18.75	22.38	-0.10	3.00	3.52	19.74	8.72	7.30	
111.00	43.48	24.36	17.09	18.08	168.80	18.25	20.57	0.10	-14.00	4.07	18.75	8.55	7.30	
122.00	40.12	24.36	17.12	17.42	173.12	18.08	19.24	-0.10	-17.00	3.52	18.25	8.21	7.20	
137.00	37.70	24.36	17.12	17.42	178.40	18.08	18.91	0.10	0.00	3.52	18.25	8.21	7.20	
148.00	36.74	24.36	17.09	17.42	179.64	18.08	18.75	-0.10	17.00	3.52	18.08	8.55	7.00	
159.00	35.28	24.36	17.09	17.25	181.17	18.08	18.41	0.10	-6.00	3.52	18.08	8.72	7.20	
171.00	51.73	25.02	17.12	21.39	186.15	19.74	28.29	0.00	59.00	2.88	21.06	8.21	7.30	DHW venting unstable.
182.00	76.88	27.18	17.08	24.39	190.05	20.10	33.69	0.00	-91.00	2.88	27.01	8.58	7.30	
197.00	89.42	26.03	17.12	21.92	188.81	19.94	28.98	-0.10	-97.00	3.52	22.91	8.08	7.30	
208.00	81.74	25.37	17.12	19.77	192.12	19.27	25.05	0.00	31.00	3.52	20.60	8.75	7.30	
219.00	89.27	25.05	17.12	22.74	196.82	19.11	30.93	0.00	-3.00	3.52	25.05	8.58	7.30	
231.00	104.43	25.21	17.08	24.22	198.20	20.93	37.89	0.00	-3.00	3.52	26.69	8.92	7.50	
242.00	118.89	31.42	17.12	26.03	156.94	20.60	33.53	-0.10	-336.00	2.88	26.69	8.92	10.70	DHW shut off. DHW and furnace
257.00	115.55	30.12	17.15	21.92	114.83	21.59	32.56	0.00	0.00	2.88	26.19	9.42	11.40	backdrafting
268.00	110.74	29.14	17.15	21.09	94.50	20.93	33.21	0.00	-17.00	3.52	27.34	9.09	10.10	
279.00	100.00	27.34	17.15	19.11	81.28	20.10	28.00	0.00	-28.00	3.52	22.58	9.09	9.20	
291.00	89.57	26.36	17.15	18.28	72.14	19.27	23.90	0.00	-183.00	3.52	20.60	9.09	8.60	
302.00	79.48	25.72	17.10	17.97	63.98	18.80	21.11	-0.10	25.00	3.52	19.29	8.77	8.00	
317.00	70.77	25.56	17.10	17.80	56.65	18.46	19.62	-0.10	-31.00	2.88	18.80	8.77	7.60	
328.00	64.14	25.23	17.10	17.47	50.99	18.30	18.80	-0.10	0.00	3.52	18.46	8.77	7.40	
339.00	60.25	25.39	17.14	18.13	51.31	19.13	18.96	0.00	-135.00	3.52	21.77	8.26	8.10	DHW and furnace venting
351.00	58.38	25.72	17.14	18.30	50.52	18.80	20.62	-0.10	-31.00	3.52	22.93	8.26	10.10	unstable
368.00	56.79	25.74	17.19	18.15	47.05	19.15	22.78	0.00	-477.00	3.52	22.12	8.79	8.90	DHW backdrafting.
384.00	50.22	25.41	17.16	17.82	44.02	18.82	20.97	0.10	-172.00	3.52	20.14	8.96	8.20	
395.00	46.89	25.25	17.16	17.49	41.63	18.82	19.98	0.10	355.00	3.52	19.15	8.62	7.90	
406.00	43.70	25.09	17.16	17.32	36.16	18.48	18.98	0.00	-25.00	3.52	18.82	8.62	7.80	
418.00	40.82	25.09	17.16	17.32	30.16	18.32	18.32	-0.10	-14.00	3.52	18.32	8.62	7.40	
429.00	38.09	24.76	17.16	17.32	27.05	18.15	18.15	0.00	0.00	3.52	18.15	8.79	7.20	
444.00	35.67	24.76	17.16	17.32	29.67	18.15	17.99	-0.20	3.00	3.52	18.15	8.79	7.00	
455.00	33.89	24.59	17.16	17.32	27.87	18.32	17.99	0.00	-20.00	3.52	18.15	8.79	6.90	
466.00	32.11	24.59	17.16	17.32	27.54	18.15	17.99	0.00	91.00	3.52	17.99	8.96	6.90	
478.00	30.97	24.59	17.16	17.49	30.81	18.15	18.48	0.20	-343.00	3.52	18.98	8.62	8.40	
478.00	30.97	24.59	17.00							0.00				
91.00	17.99	8.96	6.90											
478.00	30.97	24.59	17.16	17.49	0.00	30.81	18.15	18.48	0.20	-343.00	0.30	1.00		

DHW VENT CONNECTOR TEST RUN 1

25/2/87 sebshouse DURATION=600 s House Pressure: -5 Pa

Configuration: Direct to chimney, 0.2m above and perpendicular to furnace pipe/chimney connection.

Legend

t13: Temperature of flue gas @ 0.3m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
0.00	26.88	17.65	32.91	59.48	16.82	21.29	0.00	-86.00	9.09	17.98	8.45	23.90	Unsure of velocity measurement.
16.00	26.88	17.65	31.94	59.48	16.82	21.29	0.00	-20.00	8.86	18.31	8.45	23.80	
27.00	26.88	17.65	29.01	59.48	16.82	21.29	0.00	155.00	8.63	17.98	8.45	23.80	
38.00	26.88	17.65	31.61	59.48	16.82	21.29	0.00	-33.00	8.63	17.98	8.28	23.80	
49.00	26.88	17.65	33.40	59.48	16.82	21.29	0.00	-308.00	7.61	18.31	8.11	23.80	
61.00	26.88	17.65	33.24	59.48	16.82	21.29	0.00	255.00	4.55	18.31	8.11	23.80	
74.00	26.88	17.65	38.25	59.48	16.82	21.62	0.00	-6.00	4.98	20.79	8.11	23.10	
87.00	27.21	17.65	35.02	59.64	17.98	23.27	0.00	-143.00	4.07	22.12	8.11	20.20	
98.00	27.54	17.65	33.08	59.79	18.48	23.76	0.00	-156.00	6.10	22.28	8.28	18.10	
109.00	27.54	17.65	36.15	60.11	19.31	23.76	0.00	-156.00	7.88	26.23	8.61	17.30	
121.00	27.70	17.65	36.80	78.12	19.47	23.43	0.00	-28.00	9.09	27.86	8.45	17.50	Started DHW, 9 s backdraft @ DHW dilution
134.00	28.35	17.65	151.76	173.86	18.81	23.93	0.00	-3.00	9.09	22.45	8.28	21.20	
147.00	27.86	17.65	166.90	214.76	17.98	22.94	0.00	0.00	9.32	20.30	8.45	25.00	
158.00	27.70	17.65	172.33	239.32	17.65	22.45	0.00	-3.00	9.54	19.80	8.28	27.40	
169.00	27.54	17.65	163.97	256.12	17.48	22.28	0.00	-11.00	8.13	19.47	8.28	29.50	
181.00	27.54	17.65	122.69	214.90	17.15	22.12	0.00	-256.00	7.61	19.47	8.11	30.60	Stopped DHW heater
195.00	27.54	17.65	98.99	184.82	17.65	22.28	0.00	-14.00	7.61	19.64	8.11	30.10	
208.00	27.54	17.65	89.90	167.32	17.48	22.61	0.00	37.00	7.04	19.80	8.11	29.70	
219.00	27.54	17.65	84.79	156.40	17.15	22.61	0.00	-31.00	7.33	20.30	8.11	29.20	
230.00	27.54	17.65	82.37	146.97	17.15	23.10	0.00	42.00	7.04	20.63	7.77	28.90	
242.00	27.72	17.67	78.29	138.33	17.17	23.12	0.00	0.00	7.61	20.81	7.79	28.50	
256.00	27.72	17.67	71.88	131.33	17.50	23.29	0.00	-102.00	7.33	20.65	7.79	28.30	
269.00	27.72	17.67	69.88	124.87	17.50	23.12	0.00	14.00	6.74	20.48	7.79	28.10	
280.00	27.72	17.67	66.49	119.95	17.17	23.12	0.00	-3.00	7.04	20.65	7.62	27.90	
291.00	27.72	17.67	67.88	115.45	17.67	23.29	0.00	-143.00	7.04	21.15	7.62	27.50	
303.00	27.74	17.69	64.96	111.10	17.52	23.31	0.00	-153.00	7.04	20.67	7.81	27.40	
317.00	27.74	17.69	60.77	106.70	17.19	23.47	0.00	-3.00	6.74	20.67	7.64	27.30	
330.00	27.74	17.69	59.36	102.87	17.19	23.31	-0.10	0.00	7.04	21.16	7.64	27.00	
341.00	27.74	17.69	59.52	99.77	17.19	23.80	0.10	65.00	6.74	21.50	7.47	26.90	
352.00	27.74	17.69	53.56	96.80	17.19	23.47	0.00	74.00	6.74	21.66	7.64	26.70	
370.00	27.74	17.69	59.36	92.48	17.19	23.80	0.30	-33.00	6.43	21.99	7.47	26.40	
384.00	27.74	17.69	54.19	89.94	17.85	24.13	0.00	-3.00	6.43	22.49	7.47	26.20	Partial backdrafting of DHW
397.00	27.74	17.69	54.35	87.38	17.69	24.13	0.00	-14.00	6.74	22.98	7.64	25.70	
408.00	27.90	17.69	59.36	85.58	17.85	24.30	0.10	-3.00	6.74	23.97	7.64	25.60	
419.00	27.90	17.69	57.80	83.92	17.85	24.46	0.10	0.00	6.43	23.14	7.47	25.60	
431.00	27.92	17.71	55.00	81.97	17.71	24.32	-0.10	-191.00	6.43	22.67	7.49	25.60	
444.00	27.92	17.74	32.16	80.31	17.71	24.32	0.00	-675.00	6.43	23.49	7.49	25.50	
457.00	27.92	17.74	56.25	78.94	17.71	24.48	-0.10	0.00	6.43	23.99	7.49	25.30	
468.00	27.92	17.74	56.25	77.57	17.87	24.81	0.00	-241.00	6.43	25.14	7.33	25.20	
479.00	27.92	17.74	56.88	76.50	18.04	24.97	0.00	0.00	6.43	25.63	7.33	24.90	
491.00	27.92	17.74	54.21	75.13	17.87	24.97	0.00	-86.00	6.74	23.33	7.33	25.10	
505.00	27.92	17.71	53.42	74.06	18.04	24.48	-0.10	-25.00	6.74	22.51	7.33	25.20	
518.00	27.92	17.71	52.01	72.99	17.87	24.32	-0.10	0.00	6.74	22.34	7.33	25.20	
529.00	27.92	17.71	50.90	72.22	17.87	24.15	0.00	-343.00	6.74	21.35	7.33	25.30	
540.00	27.76	17.71	49.00	71.30	17.71	23.99	0.00	-840.00	6.74	21.18	7.33	25.30	
552.00	27.79	17.74	50.14	70.56	17.74	24.02	0.10	-169.00	7.04	22.21	7.36	25.20	
565.00	27.79	17.74	48.19	69.79	17.74	24.35	0.00	0.00	6.74	21.38	7.02	25.30	
578.00	27.79	17.74	47.29	69.02	17.74	24.02	0.00	0.00	7.04	20.88	7.02	25.30	
589.00	27.79	17.74	49.03	68.41	17.74	24.02	0.00	108.00	0.00	21.21	7.02	25.30	

DHW VENT CONNECTOR TEST RUN 2
26/02/87 sabshouse DURATION=480 s House Pressure: -7 Pa

Configuration: Direct connection to chimney, 0.2m above and perpendicular to the furnace vent connector.

Legend

t2: Temperature of DHW connector wall 0.2m above dilution
t3: Temp. of chimney wall 0.5m above furnace pipe/chimney connection
t4: Temperature indoors
t5: Temp. DHW flue gas 0.2m above dilution
t7: Temp. DHW combustion gases before dilution
t8: Temp. furnace dilution air
t9: Temp. of furnace flue gas @ furnace pipe/chimney connection
t10: wind strength
t11: wind direction
t12: Air velocity in DHW vent connector, l/s (ERR indicates backflow)
t13: Temp. furnace flue gas 0.3m above dilution
t14: Outdoor temp.
t15: Temp. flue gas 0.5m below chimney cap

Time (s)	t2	t3	t4	t5	t7	t8	t9	t10	t11	t12	t13	t14	t15	Comments
0.00	24.22	27.66	17.61	27.99	31.09	23.89	24.71	0.00	-25.00	ERR	27.82	8.40	13.60	DHW and furnace backdrafting.
16.00	24.22	27.66	17.61	26.19	28.48	21.42	23.72	-0.10	0.00	ERR	23.23	8.74	11.90	
27.00	23.72	27.17	17.61	24.05	27.50	20.59	22.41	0.00	-613.00	2.88	21.58	9.25	10.70	
38.00	23.72	27.01	17.61	25.53	28.64	20.59	22.41	0.20	0.00	4.55	24.38	8.57	11.10	
49.00	23.72	27.17	17.61	25.86	29.29	20.26	23.23	0.00	-136.00	2.03	29.29	8.40	11.30	
61.00	23.68	27.46	17.57	31.05	82.60	21.38	24.18	-0.20	304.00	4.07	25.16	8.36	10.30	Start DHW. DHW venting unstable,
76.00	55.18	27.46	17.57	100.15	137.67	23.03	27.95	-0.10	11.00	2.03	25.66	8.20	9.70	furnace backdrafting
87.00	60.19	27.13	17.57	98.77	155.49	22.37	25.82	0.00	0.00	ERR	23.19	8.36	9.20	At 120s, slight short circuit for
98.00	46.65	26.97	17.57	64.38	166.42	21.38	23.35	-0.10	-6.00	2.03	21.21	8.53	8.70	several seconds
110.00	50.77	26.80	17.57	71.17	176.99	20.71	23.03	-0.10	34.00	5.75	20.71	8.53	8.60	
121.00	73.78	27.95	17.57	163.06	183.93	21.05	31.21	-0.10	-995.00	2.03	25.98	8.36	8.20	
136.00	87.43	27.62	17.57	174.35	188.08	20.71	32.51	0.10	-64.00	4.07	25.49	8.36	8.10	
147.00	103.95	27.95	17.57	194.43	191.39	22.20	33.00	0.10	-280.00	0.00	26.64	8.53	8.00	
158.00	93.72	27.46	17.57	139.38	189.46	21.05	27.78	0.00	0.00	ERR	22.53	8.70	7.80	
170.00	79.57	26.97	17.57	87.58	189.46	20.38	24.18	0.00	-248.00	2.03	21.05	9.54	7.50	
181.00	73.78	26.80	17.57	71.63	190.98	20.05	22.04	0.00	20.00	ERR	20.22	9.21	7.40	
196.00	65.78	26.64	17.57	55.18	189.87	19.39	20.71	0.00	187.00	ERR	19.72	9.21	7.30	
207.00	60.65	26.64	17.57	47.92	192.22	19.56	20.05	0.00	17.00	4.98	19.56	9.21	7.30	
218.00	78.05	27.13	17.57	154.23	194.43	20.05	29.74	0.20	-135.00	4.98	24.34	8.70	7.50	
230.00	93.42	27.95	17.57	206.29	196.09	24.01	39.94	0.00	-105.00	6.43	28.44	8.03	7.80	
241.00	98.01	32.82	17.55	220.74	196.90	23.17	36.38	0.10	-759.00	8.86	26.46	8.18	13.50	Venting stable.
256.00	101.42	32.82	17.55	205.17	197.73	20.36	29.40	0.00	-6.00	8.38	22.51	8.51	22.30	
267.00	105.99	31.19	17.55	195.24	191.10	18.87	26.46	0.10	-25.00	7.61	21.36	8.18	24.70	At 270s, DHW shut off.
278.00	103.55	30.54	17.55	146.88	133.80	18.54	25.14	-0.10	25.00	6.43	22.84	8.34	23.50	
290.00	104.66	30.21	17.55	129.51	106.58	17.88	25.14	-0.10	0.00	6.43	23.66	8.51	23.60	
301.00	102.16	29.72	17.55	112.73	88.16	17.88	25.14	0.10	-64.00	6.43	22.84	9.02	24.40	Furnace venting unstable.
316.00	96.82	29.40	17.55	95.34	77.57	17.55	24.32	0.20	76.00	6.43	22.02	8.68	25.00	
327.00	92.06	29.40	17.55	89.36	70.85	17.55	24.32	0.00	-72.00	4.55	24.98	8.51	24.50	
338.00	88.91	29.72	17.55	89.66	65.45	22.02	26.78	-0.10	-3.00	4.55	24.98	9.02	21.60	DHW venting unstable. Furnace
350.00	85.75	29.72	17.55	85.75	60.95	23.17	29.56	0.00	-58.00	3.52	27.93	8.18	18.60	backdrafting
368.00	80.16	30.54	17.55	74.98	54.53	22.18	28.42	0.00	-6.00	6.43	25.47	8.01	18.90	
383.00	74.98	30.05	17.55	65.60	51.38	20.03	25.96	-0.10	0.00	4.98	23.66	8.18	20.50	Furnace venting unstable.
394.00	70.69	29.56	17.55	62.81	48.85	19.37	25.64	-0.10	11.00	4.07	25.64	8.34	20.20	
405.00	67.46	29.40	17.55	62.19	46.47	19.54	25.14	0.00	-664.00	4.07	28.91	8.18	19.20	
417.00	64.67	29.40	17.55	61.10	44.40	19.54	25.47	0.00	-50.00	6.10	29.40	8.01	18.70	
428.00	61.26	29.24	17.55	52.17	42.16	18.54	24.81	0.00	59.00	8.13	22.35	8.01	20.90	
443.00	56.10	28.75	17.55	45.36	40.40	17.71	23.83	-0.10	0.00	11.14	20.53	8.18	22.20	
454.00	51.54	28.58	17.55	41.20	38.95	17.55	23.17	0.00	-124.00	7.88	20.36	8.18	22.50	
465.00	47.58	28.42	17.55	38.15	37.50	17.38	23.01	0.20	-6.00	8.38	19.70	8.01	23.10	
477.00	44.08	28.26	17.55	36.05	36.38	17.05	22.84	-0.20	0.00	6.10	20.03	7.67	23.10	
														At 540s, DHW and furnace backdrafting

APPENDIX C

DEFINITION OF TERMS

Chimney house buoyancy pressure

- the net buoyancy in the column of flue gas in the chimney relative to outdoor air minus the net buoyancy of the house air at standby. (The net buoyancy of the house air is the buoyancy of the column of house air measured from the dilution device to the envelope's vertical centre of leakage.)

Furnace buoyancy (Pa)

- the total buoyancy of the column of gas in the furnace relative to the adjacent column of air in the furnace room. Vertical Centre of Leakage (VCL) is the vertical location on the house wall at which all leakage sites of the envelope appear to be acting. For an even distribution of leaks top and bottom, the VCL is half-way up the wall. Large leakage sites at the top of the house (e.g. a loose attic hatch) tend to raise the VCL. Large openings at ground level (e.g. an outdoor air intake) pull the VCL down. All of the heated indoor air <u>below</u> the VCL competes with the chimney. If the VCL could be brought down to ground level, this would eliminate the house as a competing chimney.